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February 25-March 2—Chemical Industries Exposition, Grand Central Palace, New York.

March 4—Society of Automotive Engineers, German Engineering Evaluation meeting, Rackham Educational Memorial, Detroit.

March 7—California Natural Gasoline Association, monthly meeting, Rio Hondo Golf Club, Downey.

March 11-12—Oklahoma Utilities Association, Biltmore Hotel, Oklahoma City.

March 11-12—Kansas Oil Men's Association, annual convention, Broadview Hotel, Wichita.

March 14-15—Indiana Independent Petroleum Association, spring convention, Hotel Severin, Indianapolis.

March 25-27—Western Petroleum Refiners Association, 34th annual meeting, Blackstone Hotel, Fort Worth, Texas.

April 1-2—Society of Exploration Geophysicists, annual meeting, Chicago.

April 2-4—American Association of Petroleum Geologists, annual meeting, Stevens Hotel, Chicago.

April 3-5—Society of Automotive Engineers (Aeronautic), spring meeting, Hotel New Yorker, New York.

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April 11-12—Independent Oil Men's Association of New England, Statler Hotel, Boston, Massachusetts.

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April 23-25—Southwestern Gas Measurement Short Course, University of Oklahoma, Norman.

April 29-30, May 1—Independent Petroleum Association of America, midyear meeting, Houston, Texas.

May 7-9—National Association of Corrosion Engineers, President Hotel, Kansas City, Missouri.

June 2-7—Society of Automotive Engineers, semi-annual meeting, French Lick, Indiana.

June 13-14—API, spring meeting, division of production, Pittsburgh.

June 24-28—ASTM, annual meeting, Buffalo, New York.

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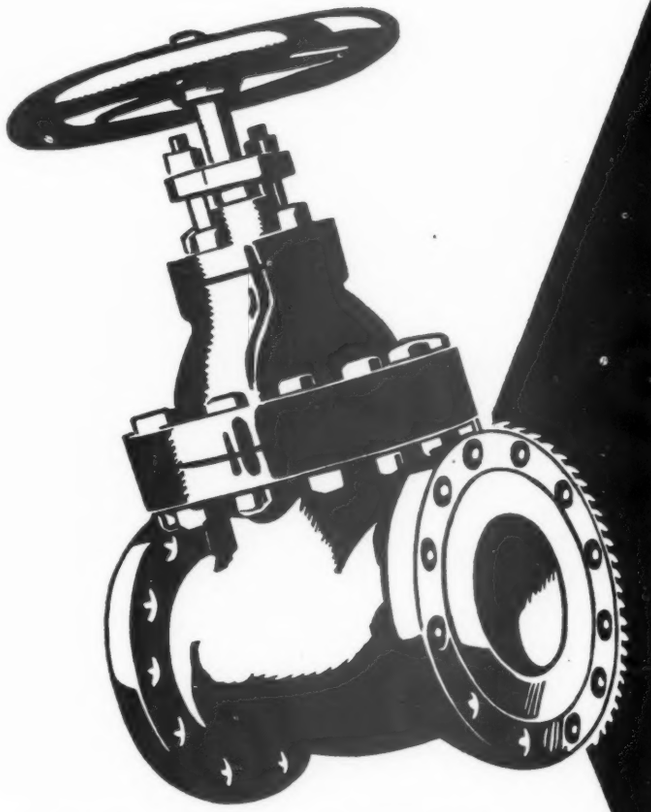
GOVERNMENT-OWNED WAR SURPLUS



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177-1

The Course of Oil

by K. C. SCLATER

OUTLOOK FOR 1946

The oil industry faces the unusual experience in 1946 of a sharp decline in demand, so stated Richard J. Gonzalez, petroleum economist, in discussing the trends in petroleum operations before the Interstate Oil Compact Commission at its last quarterly meeting.

In discussing the outlook for the year ahead, Gonzalez sounded a note of warning and pointed out that 1946 will mark the difficult phase of the postwar transition for the oil industry. "Total anticipated requirements of about 4,800,000 bbl. daily will be about 10 per cent less than in 1945. This will be the largest decline in the history of the industry, exceeding the decrease of 9 per cent in 1932. Except for the depression years of 1930-1932, petroleum consumption has decreased in only three years in the past quarter century—1921, 1938, 1942—and then only by 1 or 2 per cent. The industry is so accustomed to steadily expanding volume that a decline of the magnitude indicated for next year presents difficult problems. . . .

"The probable output of crude oil required to balance demands in 1946 will be about 4,150,000 bbl. daily, representing a decrease of over 500,000 or 11 per cent. The difference between the production peak of 4,890,000 in July, 1945, and the low point of about 4,200,000 early in 1946 will result in a maximum range of about 700,000 bbl. daily or 15 per cent. Since this change will probably be concentrated to a large extent on the areas that were called upon to supply so much of the additional oil for war, the greatest shock will be felt in Texas and California. The problem is a general one, however, and producers of all states should be forewarned of the decline that will occur in requirements for crude oil.

"Lower production in 1946 will mean a sharp increase in the unit cost of producing crude oil. During the war, rising costs for labor and materials were substantially offset by larger volume, so that the usual accounting methods reflected only a moderate increase in cost per barrel. The sharp decline in volume next year, together with advancing wage rates, will exert a cumulative influence to bring about much higher unit costs of production than indicated for 1944-45. This development and the high replacement cost being experienced generally throughout the industry provide convincing proof of the need for an increase in ceiling prices on crude oil and refined products, or complete removal of such ceilings at an early date, so that normal economic forces may be allowed to determine price levels conducive to the sound functioning of the industry for the future.

"The year 1946 will mark the difficult phase of the postwar transition for the oil industry. Unless some unusual circumstances arise, it is anticipated that the upward trend in petroleum demand will be resumed in 1947 and continue at a moderate rate for several years thereafter. It is essential, therefore, that the necessary adjustments be made promptly and smoothly, so that a sound basis may exist for future developments. The problems ahead can be overcome just as efficiently as those encountered in supplying unprecedented wartime demands. While changes in volume will be large, it should be borne in mind that 1946 operations will still be well above the record level of 1941. The adjustments in 1946 can be made with minimum difficulty if they are approached with understanding and intelligent cooperation by operators, State regulatory agencies, and the Interstate Oil Compact Commission. If freed from restrictive wartime regulations and given reasonably favorable conditions, the oil industry may be expected to overcome the transition problems and to continue its maximum contribution to the economic welfare and progress of the nation."

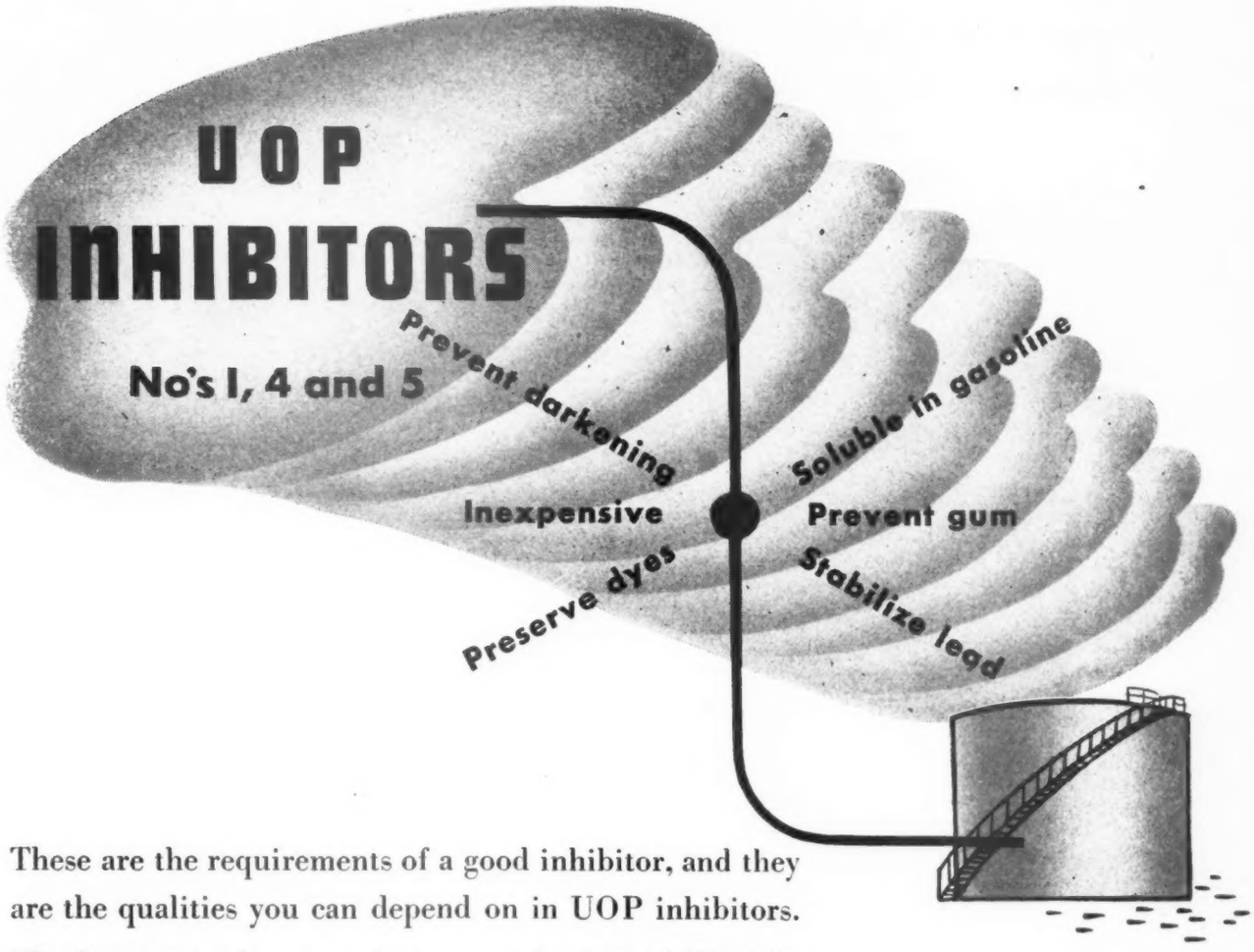
U. S. HELIUM PRODUCTION

During the last five fiscal years U. S. Bureau of Mines plants have produced 370,787,000 cu. ft. of helium, sufficient to provide enough helium to inflate a fleet of more than 50 of the huge rigid type dirigibles of the Graf Zeppelin II or Hindenburg class. These figures on the U. S. helium production have just been officially released from Washington. The official announcement also states that "During the first World War when helium was little more than a laboratory curiosity, three small American plants produced a total of only 200,000 cu. ft. of helium. . . .

"Slightly more than a quarter of a century ago, helium was produced at the rate of about $2,500 per cubic foot by then known laboratory methods, but so efficient were the Bureau's methods that during the war the gas was produced for considerably less than a cent per cubic foot."

This is a remarkable achievement in process development.

"The Bureau of Mines, since 1925 the sole Government agency charged with helium production, operated extraction plants at Amarillo and Exell, Texas, at Otis and Cunningham, Kansas, and at Shiprock, New Mexico, during the war."



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Scanning WASHINGTON'S OIL HORIZON

By MILBURN PETTY

WASHINGTON.—Chief loser in the Pauley nomination fight—with all its repercussions—will be the oil industry.

Some of the mud thrown at Edwin W. Pauley, Los Angeles oil man, during debate over his nomination as Navy Undersecretary, spattered the industry, too. Denials never quite overcome sensational headlines. And people are only too ready to believe the worst about oil men and their business.

With eyes on the fall elections, Republican senators will attempt to smear oil and politics across newspaper front pages for weeks to come.

All this cannot help but affect the relations of the industry, generally, and oil groups and companies, with Congress and the government. They will be more oil conscious. Even a fair-minded legislator or official will move slowly in doing anything of benefit to oil, which might be misinterpreted.

It will be more difficult for the industry to resist moves toward federal oil control, elimination of the depletion allowance or other attacks. Similarly, it becomes more difficult for the companies involved to negotiate an acceptable settlement in the API anti-trust case. The Truman Administration will want to avoid any flareback like that arising out of the Elkins Act pipe line consent decree in 1941, which has been brought into the Pauley nomination debate.

There was an explosive atmosphere in oil already, as has been pointed out here previously. Now, it is supercharged.

Some kind of supervision of oil policies will be attempted. It may be only a centralization of federal oil activities in the Interior Department, as has been recommended to the White House under the governmental reorganization program. Again, it may involve an interdepartment oil board at the Cabinet level, with Interior, War, and Navy represented. This, too, is being considered by President Truman.

The upshot may be that military authorities are placed in control of government oil policies. Right now, the military is rushing plans for a permanent Army-Navy Petroleum Board with a 25-member advisory committee drawn from all branches of the industry.

President Truman is unpredictable—but the odds favor him doing something toward developing a government oil policy, which may include some measures of control.

● **CONTINENTAL SHELF.** Interior Department is drafting a $4,000,000 program for oil and gas exploration by U. S. Geological Survey of the Continental Shelf, that vast undersea area that rims the United States. (Before running the gauntlet of Congress, however, this program must be approved by the Budget Bureau.)

For the present, this program is limited to submerged lands beyond the three-mile limit. But if the government is successful in its tidelands claims, then all of this submerged area, from low tide on out, will be under federal control.

With funds now available, Interior is making a stab at exploring the Shelf for oil and gas deposits off the Gulf Coast. This survey is about to get under way. It will be under supervision of the Geological Survey. A Navy PBY plane is being equipped with an airborne magnetometer. Army engineers will provide shore stations for triangulation. Base will be at Lake Charles, Louisiana. Area to be explored lies along the Louisiana and Texas shoreline for about 160 miles westward from Lake Charles.

This Gulf Coast area is one of the richest in oil and gas possibilities. So this quickie survey with the "flying doodlebug" is bound to produce results which Interior can use in pressing for a large appropriation from Congress to carry on similar work elsewhere.

● **IMPORTS.** Support is growing for the proposed conference of state officials, importing oil companies, domestic producers and federal agencies looking toward the development of a national policy on imports. Currently, imports are running perhaps more than 400,000 bbl. daily. With the prospect that the present 10½ cents per barrel import tax may be cut to 5¼ cents in the next trade treaty, as authorized, producers are fearful of a flood of foreign oil.

● **OIL TREATY.** Rumblings from Texas against the Anglo-American oil agreement have reached Senator Tom Connally, Texas, in London where he is attending the UNO conference. He has cabled a postponement of the Senate Foreign Relations Committee's hearings on the oil treaty until March 4 when he can be back here to preside personally. Harry F. Sinclair's blast against the treaty may be the opening of a widening breach in the industry.

● **PIPE LINE DISPOSAL.** Industry opposition to oil use of the Big Inch pipe lines will be heard at hearings—probably around March 1—on the Surplus Property Administration's report, which insists that national security requires continued use of the lines as oil carriers; also, that the lines are competitive with tankers.

By time of the hearings, SPA expects to be ready with a report on its efforts to arouse interest in purchase, lease, or use of the lines as oil carriers. Approximately 5000 producers, refiners and marketers, plus the cooperatives, are being contacted by SPA on the possibility of organizing a joint corporation to operate one or both of the lines.

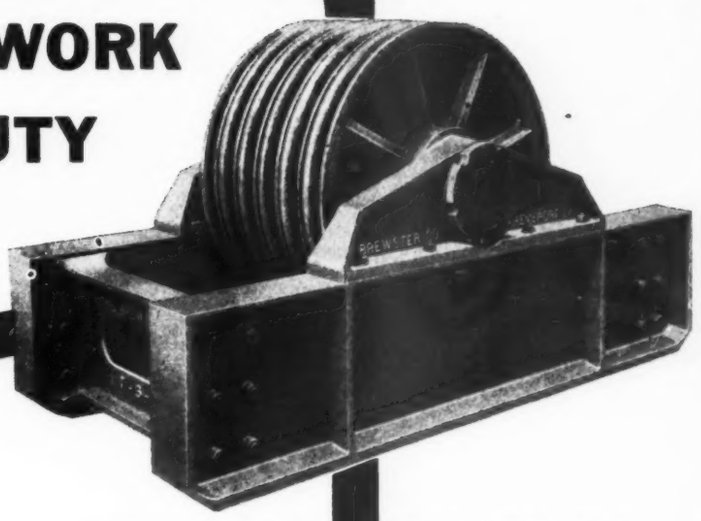
● **CRUDE PRICES.** The fight for higher crude prices is being pushed on two fronts. OPA's National Crude Oil Advisory Committee is renewing its efforts for an increase of at least 35 cents in ceiling prices on crude. From another tack, the Independent Petroleum Association of America is seeking to kill oil price control entirely as the OPA extension bill comes up in Congress.

● **100-OCTANE PLANTS.** Carrying out SPA's declared policy on disposal of government-owned 100-octane plants and facilities, War Assets Corporation (RFC subsidiary) announces that preference will be given to buyers who propose to continue operating the entire plant as an entity at its present location. Next in order of preference will be continued use of process units or parts of units where now located; next, the removal and reassembly of plants, units, or parts of units without substantial change at other locations. Last choice will be sale of individual items for any use, anywhere.

● **STRIPPER WELLS.** Secretary Ickes favors continuance of the stripper well subsidy beyond June 30, the cut-off date now, if the price of crude isn't sufficiently high by then "to cover the cost of production." He also favors an annual survey by the U. S. Bureau of Mines to determine production costs and relate them to reserves, with emphasis on stripper wells. Support from producers will be sought for this proposal.

● **POSTSCRIPTS.** PAW's report on the study of underground stockpiling of foreign oil, made on orders of Ickes, indicates this idea is impractical and too expensive.... F. G. Brickwedde, 43-year-old government scientist, is new director of National Bureau of Standard's heat and power division.... Treasury Department is opposed to accelerated amortization of postwar plants for small refiners.... Sun Oil Company proposes that 100-octane stored at its Marcus Hook plant be pumped westward through the Big Inch to Phoenixville, Pennsylvania, for storage in Little Big Inch tanks.... Military authorities have decided that they can use up all 100-octane stockpiled in this country, that it won't deteriorate in the 16 months required—so it won't be dumped on the market here.... Budget Bureau's economy trend is threatening State Department's program for placing petroleum attaches in all important countries.... Proposals for a postwar advisory group, patterned after the PIWC, have been voted down—but some kind of industry-wide organization may be set up by the government.

BETTER TEAM WORK FOR HEAVY DUTY DRILLING

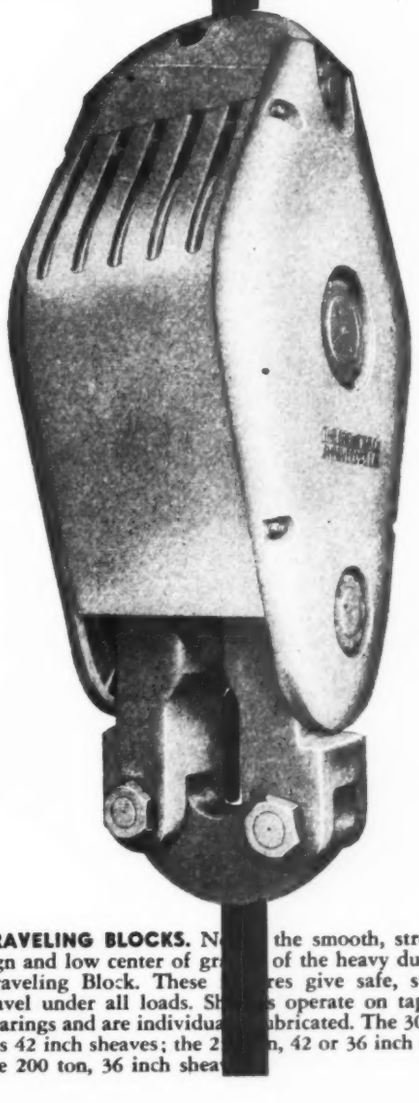


CROWN BLOCKS. The 30 n block is available with 42 or 48 inch shea es; 250 t h 36 or 42 inch sh aves and the 200 ton with 36 inch ves. Sheaves are cast electric alloy steel with machir ame hardened API grooves. Tapered roller bearings i dually lubricated are used. When used with the Comp n Brewster Traveling Block side pull is held to a mini

Teamwork is essential for efficient drilling. The crew must work together as a team—machinery must be built around load and power requirements. That is why The Brewster Company designs its Crown and Traveling Blocks to fit the team—to make drilling safer and more efficient. All sheaves are machined to API standards and have flame hardened grooves giving a better wearing surface—make drilling line last longer. Tapered roller bearings—individually lubricated—are used throughout.

The Traveling Block is smooth and streamlined to eliminate "hanging-up." Balance and a low center of gravity give true, straight line travel. Where these two blocks are used together side thrust is reduced to a minimum, further extending bearing and drilling line life. Every possible consideration has been given the design and manufacture of these blocks to make them carry heavier loads, safely and efficiently.

Brewster also makes Tubing Blocks, Combination Hook Blocks, Sand and Catline Sheaves and many other items of drilling equipment. For further information write or wire The Brewster Company or see the Composite Catalog.



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NATIONAL PETROLEUM SITUATION

PRODUCTION EXCESSIVE. Crude output in January is indicated to have been about 4 per cent above domestic requirements. One reason for this is the continued high rate of imports of foreign oil. Preliminary estimates indicate that more than 7,300,000 bbl. of foreign oil was imported, which reduced domestic productive requirements to a daily average of about 4,500,000 bbl., against actual output of 4,661,000 bbl. daily.

REFINING SITUATION UNBALANCED. With gasoline stocks piling up to the highest levels in several years and fuel oil stocks diminishing at an alarming rate, the refining situation in January presented a decidedly confusing picture. Runs to stills were too great in the light of heavy additions to gasoline storage, but too small to stem the tide of ebbing fuel oil stocks. Thus, in one sense, the demand for crude oil has been artificially stimulated in the effort to provide adequate fuel oil supplies. Less motor fuel and more fuel oil is the answer to this problem.

GASOLINE STOCKS UP 18%. Stocks of gasoline in the U. S. reached the highest level ever recorded for January, aggregating 98,240,000 bbl. This is 18 per cent above a year ago, representing a gain of nearly 7 million bbl. in one month. The effect, in the face of curtailed demand, has been a depressing market factor and has already been felt in price-cutting in various sections of the nation. This is decidedly detrimental to the cause of oil producers in their fight for justifiably higher crude oil prices.

CRUDE PARITY $2.00. On the basis of the U. S. Bureau of Labor index of all wholesale commodities, the price of crude oil in January should have been $2.00 a bbl. Actual average price, exclusive of subsidies, $1.22. The big question before oil producers now is what happens when the subsidies are discontinued in June? A price increase of at least 25 cents per bbl. is expected by many, but the prospect is dimmed by the unseasonable build-up of gasoline stocks.

DRILLING RESULTS FAVORABLE. Drilling operations in January were about 13 per cent above a year ago. Well completions were maintained at a level somewhat above the annual rate of 27,000, which was the 1945 quota. This year's outlook calls for drilling at least 28,100 wells, of which not less than 5,000 should be wildcats. On this basis, January results were within 1 per cent of quota. The fact remains, however, that 27,000 wells last year failed to bring in sufficient major field discoveries and if this year's results are no better than last year. 1100 more wells may not greatly affect the reserves picture. Favorable economic conditions, accompanied by a substantial price advance for crude is the one real incentive to more wildcatting.

Comparative Statistics, January, 1946

*All figures are computed on a Bureau of Mines' Basis**

	Jan. 1946	Dec. 1945	Jan. 1945	This year to date	Last year to date	Per cent change
Wells drilling	4,260	4,200	4,150	4,260	4,150	+ 3
Total wells drilled	2,357	2,347	2,081	2,357	2,081	+13
Development wells	2,012	2,047	1,735	2,012	1,735	+16
Oil	1,264	1,241	1,068	1,264	1,068	+18
Gas	201	221	193	201	193	+ 4
Dry	547	585	474	547	474	+15
Per cent dry	27.2	28.6	27.3	27.2	27.3	— 0.1
Wildcat wells	345	300	346	345	346	0
Oil	35	38	46	35	46	—24
Gas	9	7	10	9	10	—10
Dry	301	255	290	301	290	+ 4
Per cent dry	87.2	85.0	83.8	87.2	83.8	+ 3.4
Crude production	144,500	¶139,575	147,186	144,500	147,186	— 2
Daily average	4,661	4,502	4,748	4,661	4,748	
Crude demand†	146,600	¶142,950	150,167	146,600	150,167	— 2
Daily average	4,729	4,611	4,844	4,729	4,844	
Crude stocks	224,365	222,750	227,763	224,365	227,763	— 1
Days supply	47	48	47	47	47	
Natural gasoline production	9,025	9,750	9,603	9,025	9,603	— 6
Daily average	291	314	310	291	310	
Motor fuel production	62,240	67,150	66,662	62,240	66,662	— 7
Daily average	2,008	2,166	2,150	2,008	2,150	
Gasoline yield, per cent	39.2	41.2	40.3	39.2	40.3	+ 1.1
Motor fuel demand	55,315	58,451	61,698	55,315	61,698	—10
Daily average	1,784	1,886	1,990	1,784	1,990	
Motor fuel stocks	98,240	91,215	83,037	98,240	83,037	+18
Days supply	55	48	42	55	42	
Fuel oil production	62,365	60,060	62,418	62,365	62,418	0
Daily average	2,012	1,937	2,013	2,012	2,013	
Fuel oil demand	78,925	74,384	78,254	78,925	78,254	+ 1
Daily average	2,546	2,399	2,524	2,546	2,524	
Fuel oil stocks	65,650	76,910	76,042	65,650	76,042	—14
Days supply	26	32	30	26	30	
Refinery still runs	141,350	143,300	145,071	141,350	145,071	— 3
Daily average	4,560	4,623	4,680	4,560	4,680	
All refined stocks	242,550	248,900	234,625	242,550	234,625	+ 3
Days supply	46	48	43	46	43	

*Unless otherwise stated all figures represent thousands of barrels.
†Domestic and foreign. ¶Revised.

Economic Position of U. S. Petroleum Industry

One Month Ending January 31, 1946

	Normal	Actual	Per cent of normal
Drilling*** (wells completed)	2,387	2,357	99
Production (daily crude output)	4,500	4,661	104
Refining (daily still runs)	4,687	4,560	97
Stocks (crude and refined)	485,000	466,915	96
Price of crude (per bbl.)	$2.00	$1.22	$0.61

Crude Prices by States for January, 1946§

U. S. average	$1.22	Louisiana	$1.20
Texas	1.23	Arkansas	1.25
California	1.07	New Mexico	1.04
Oklahoma	1.17	Mississippi	1.10
Kansas	1.17	Illinois	1.37
		Other states	1.89

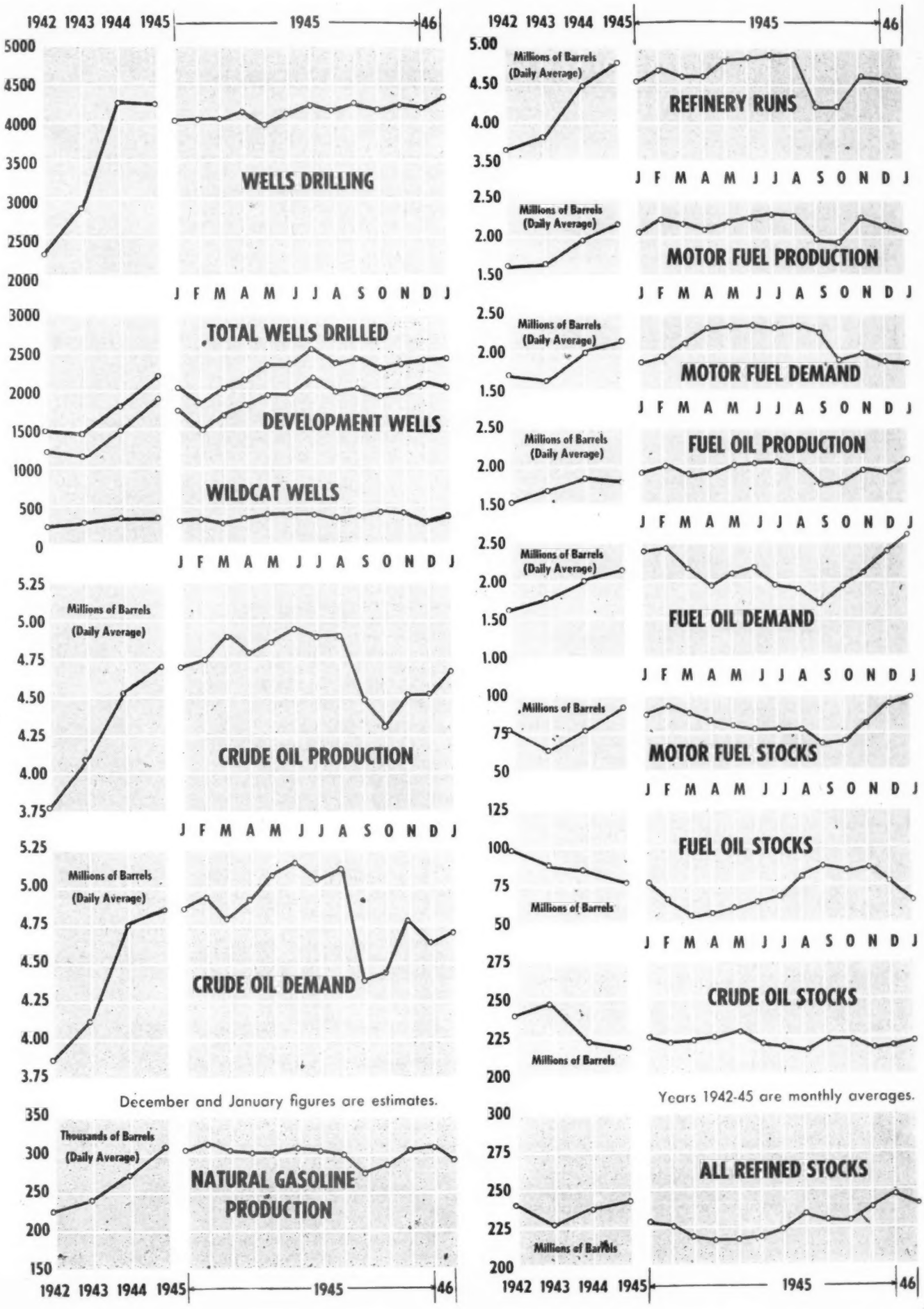
Basic crude prices

Oklahoma-Kansas (36 gr.)	$1.27
Texas Gulf Coast (36 gr.)	1.40
East Texas	1.25
West Texas (36 gr.)	1.04
Calif. Signal Hill (26 gr.)	1.11
Pennsylvania	3.00

Drilling and Production Statistics by States

	Jan. 1946	Dec. 1945	Jan. 1945	This year to date	Last year to date	Per cent change
Total wells drilled	2,357	2,347	2,081	2,357	2,081	+13
Texas	675	645	552	675	552	+22
California	156	146	221	156	221	—29
Oklahoma	212	237	195	212	195	+ 9
Kansas	191	191	112	191	112	+71
Louisiana	102	121	81	102	81	+26
Arkansas	11	23	13	11	13	—15
New Mexico	44	38	41	44	41	+ 7
Mississippi	23	18	26	23	26	—12
Illinois	178	153	169	178	169	+ 5
Other states	765	775	671	765	671	+14
Wildcats drilled	345	300	346	345	346	0
Texas	108	125	126	108	126	—14
California	24	16	22	24	22	+ 9
Oklahoma	54	42	34	54	34	+59
Kansas	31	20	35	31	35	—11
Louisiana	10	15	16	10	16	—37
Arkansas	1	8	4	1	4	—75
New Mexico	10	4	8	10	8	+12
Mississippi	5	4	10	5	10	—50
Illinois	41	19	36	41	36	+14
Other states	71	46	55	71	55	
Daily crude production	4,661	4,502	4,748	4,661	4,748	— 2
Texas	2,055	1,910	2,159	2,055	2,159	— 5
California	842	842	892	842	892	— 6
Oklahoma	398	389	364	398	364	+ 9
Kansas	249	247	268	249	268	— 7
Louisiana	368	373	347	368	347	+ 6
Arkansas	77	76	81	77	81	— 5
New Mexico	101	97	104	101	104	— 3
Mississippi	54	55	48	54	48	+13
Illinois	222	226	205	222	205	+ 8
Other states	295	287	280	295	280	+ 5

§No change since prices frozen. Prices do not include subsidies.
(p) Preliminary. ***Does not include input wells.



December and January figures are estimates.

Years 1942-45 are monthly averages.

Highlights IN OILDOM

● **TO DIVULGE GERMAN LUBRICATING OIL SECRETS.** The navy has announced it will soon turn over to private industry secret German processes for producing synthetic lubricating oil said to have three times the service life of corresponding American products. The processes were discovered by a navy mission in Germany. The navy also discovered a German synthetic diesel fuel with performance characteristics far superior to any product now available in the United States, it is asserted.

The information uncovered in Germany will save American industry years of expensive research in developing synthetic fuels and lubricants, the navy said.

Samples of the new German synthetic lubricating and fuel oils are undergoing tests at the navy's research laboratory at Suitland, Maryland. The information will be released when the tests are completed, the navy said.

● **API ANALYTICAL RESEARCH UNIT.** Appointment of a new standing committee of the American Petroleum Institute, the committee on analytical research, has been announced by William R. Boyd, Jr., president.

The new committee's principal duty will be to develop and formulate methods of analysis needed by the petroleum industry for intermediate products of manufacture and for control of manufacturing processes.

The committee is to continue in peacetime the type of activity conducted by the analytical subcommittee of the technical advisory committee of the Petroleum Industry War Council.

Harry Levin, The Texas Company, Beacon, New York, is chairman. E. L. Baldeschwieler, Standard Oil Development Company, is vice chairman, and C. E. Headington, Atlantic Refining Company, is secretary.

Members are:

R. L. Askevold, Pure Oil Company, Chicago; G. R. Bond, Jr., Houdry Process Corporation of Pennsylvania, Linwood, Pennsylvania; P. L. Brandt, Pan American Refining Corporation, Texas City, Texas; Ralph Clark, Gulf Research and Development Company, Pittsburgh, Pennsylvania; M. J. Hartig, Standard Oil Company (Ohio), Cleveland; B. J. Henrich, Phillips Petroleum Company, Bartlesville, Oklahoma; C. K. Hewes, Richfield Oil Corporation, Wilmington, California; S. S. Kurtz, Jr., Sun Oil Company, Norwood, Pennsylvania; Robert Matteson, California Research Corporation, San Francisco, California; A. E. Miller, Sinclair Oil Corporation, New York; W. H. Naylor, Union Oil Company of California, Wilmington; J. B. Rather, Jr., Socony-Vacuum Oil Company, Inc., New York; W. W. Scheumann, Cities Service Refining Corporation, Lake Charles, Louisiana; C. T. Shewell, Humble Oil and Refining Company, Houston, Texas; E. B. Tucker, Standard Oil Company (Indiana), Whiting, Indiana; F. D. Tuemmler, Shell Development Company, Emeryville, California, and G. M. Webb, Universal Oil Products Company, Riverside, Illinois.

● **BILL WOULD ENCOURAGE SEARCH FOR OIL.** Senator H. B. Mitchell of Washington has introduced a bill to spur the search for new oil reserves and mineral deposits. The bill proposes to establish a substation with the latest geophysical equipment at one land grant college in each state offering accredited courses in mining engineering. Senator Mitchell pointed out that one major discovery would pay the cost of the project.

● **CALIFORNIA DENIES FEDERAL OWNERSHIP SUBMERGED LANDS.** In an 822-page brief filed in the United States Supreme Court, California denies that the federal government "now is or ever has been owner" of submerged land off the coast of California out to the three-mile limit. The brief contends that the "United States has no right whatever to the petroleum or gas or other hydrocarbon substances, or any rights in connection with exploring for, drilling, removing, taking or using such substances from, in or under any of the lands underlying the Pacific Ocean within the boundaries of the State of California."

The brief, signed by Robert W. Kenny, California attorney general, was filed in answer to a government suit claiming federal jurisdiction over the bed of the Pacific Ocean adjacent to the California coast "beginning at low water mark and extending seaward for three nautical miles."

The action was filed last October 19 by Attorney General Clark at the request of Secretary of Interior Ickes. At the same time, the government withdrew an earlier suit filed in federal district court in Los Angeles to prevent the Pacific Western Oil Corporation, acting under a state lease, from extracting oil from submerged lands off the California coast near Santa Barbara.

Kenny cited previous supreme court decisions, which he said affirmed that the original 13 states, "since not later than July 4, 1776," have owned all lands under navigable waters within their boundaries, "including all lands under all waters of the sea within at least three miles of their respective coasts."

He said California, by an act of Congress September 9, 1850, was admitted into the union "on an equal footing with the original states in all respects whatever," thereby becoming vested with title to lands beneath navigable waters and under the marginal sea.

He quoted the state constitution, approved by congress, as fixing the boundary line to extend "three English miles" into the Pacific Ocean.

In reliance upon previous court decisions fixing title to tide and submerged lands in the state, Kenny said, California has granted more than 100 prospecting permits, oil and gas leases and easements to tide and submerged lands. The lessees, he added, have drilled more than 350 oil and gas wells since 1921 and have spent more than $20,000,000.

Kenny contended in a statement that the government suit causes doubt on long-established titles to "billions of dollars" of property in the United States, including docks, harbors, commercial fisheries, and business and residential property built on "filled in" lands reclaimed from the marginal sea.

● **KANSAS PRORATION RULES REVISED.** Revision of Kansas's oil proration rules to include certain wartime practices, recently endorsed by a committee representing operators and the conservation division, have been announced by T. A. Morgan, director of the state conservation division.

Morgan said the state corporation commission has published to operators the revision of rules that amends the wartime rules —emergency rules 1 and 2—and incorporates them in basic rules 105 and 106.

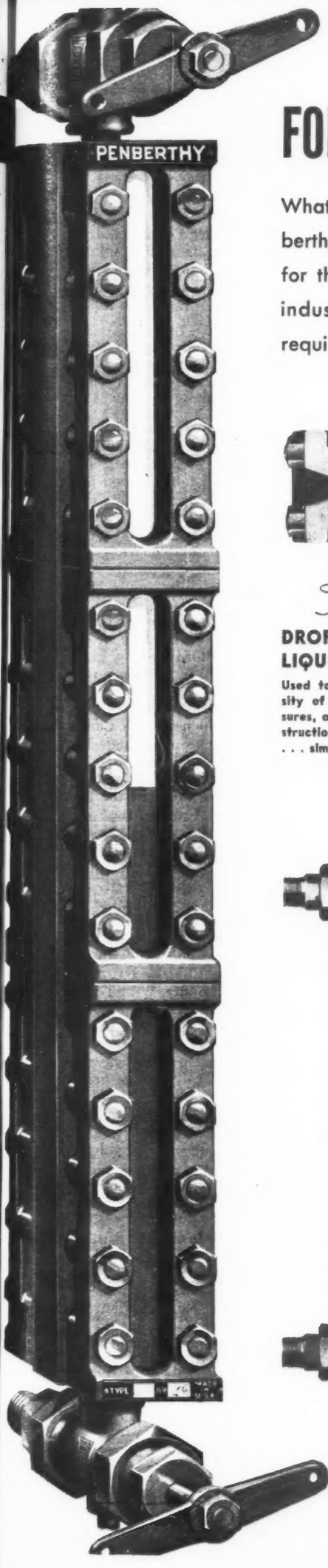
The wartime rules, which provide for a 3000-bbl. maximum daily potential rating for Kansas oil wells, establish a 15-bbl. deduction for each 1 per cent of water produced, authorize bottom-hole pressure measurement for potential calculation, and require on physical tests that wells be rated in the manner in which normally produced, were reported by the committee to be within 10 per cent accurate, and to have permitted state field crews to speed well testing, thus offsetting inaccuracy by more frequent tests.

Simultaneously the commission eliminated its supervisory control of unitization from the basic proration order for the 7-county Hugoton gas field in southwest Kansas, Morgan announced.

Where owners joined adjacent tracts in a single production unit but were unable to agree upon division of royalties, the commission has been empowered, upon application, to determine the acreage properly attributable to the production unit and to apportion royalties between landowners and holders of mineral rights.

As amended, the unitization rule places arrangements upon a contractual basis between landowners, operators, and well owners, without state intervention.

The commission ruling holds that it does not have legal authority to compel unitization or to compel drilling of gas wells on the basis of the 640-acre unit it found "to be the most economic and advantageous unit" for the Hugoton area.



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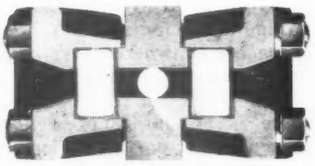

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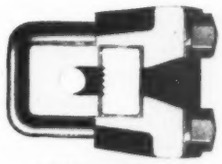

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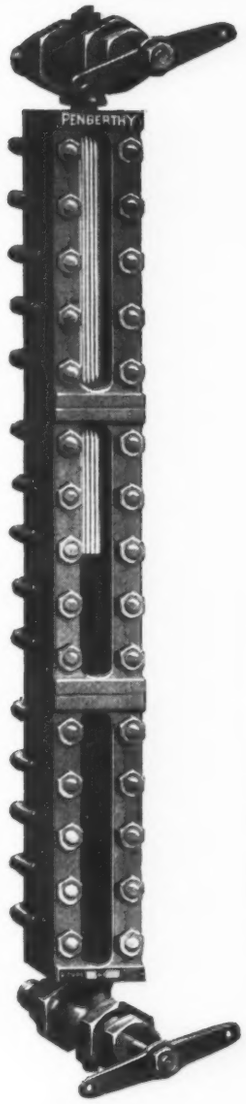

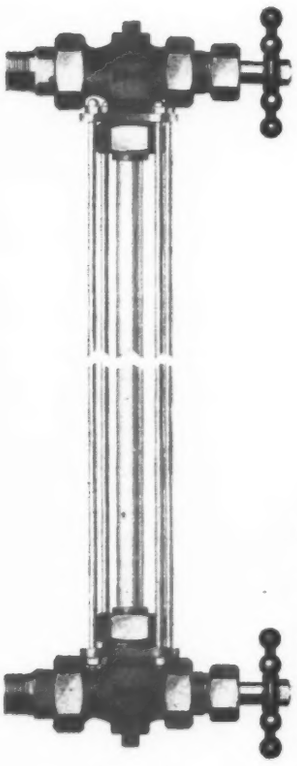

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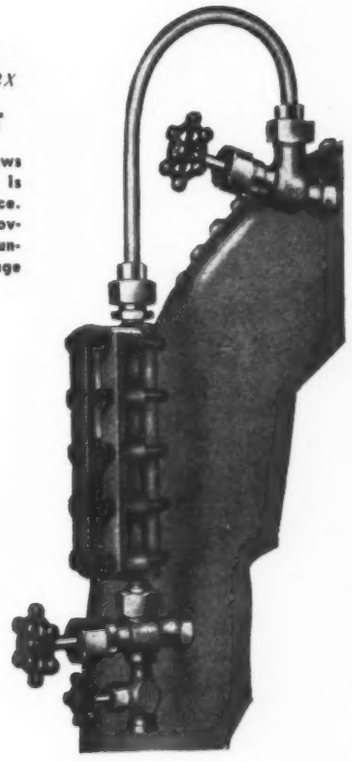

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MAJOR *Oil Field* ACTIVITIES

● **ILLINOIS.** The Deep Rock Oil Corporation No. 1 Ed Given, NW NW SE 4-2n-6e, proved to be a commercial producer opening a new pool for Clay County. The McClosky limestone in this well is found from 2978-84 ft. with the total depth of the hole at 2988 ft. The last production test showed 211 bbl. of oil in 24 hr. on the swab.

● **LOUISIANA.** Indicating prospect of a new pool in the Lafourche area is Humble Oil and Refining Company's No. 1 Delta Farms, 19-17s-23e. The well is being perforated for a production test at 10,567-70 ft. It was reported to have picked up 30 ft. of heavily saturated sand in drilling to 12,005 ft.

Crosby Drilling Company and Lyle Cummins No. 1 Gordon, 2-3s-6e, in the extreme northeast corner of St. Landry Parish in the Woodside area, is a possible pool opener. It showed odor in bottom 4 ft. of hard fine sand at 9205-15 ft. Another similar sand was cored at 9250-56 ft. Both sands are in the Wilcox.

Beauregard Parish has two new Cockfield producing pools. Magnolia Petroleum Company's No. 2 C. Lutcher-Moore, 22-5s-11w, 4 miles east of the West Pine Grove pool, was preparing to make production test after a drillstem test in perforations at 7627-31 ft. with packer set at 7618 ft. The well flowed at the rate of 175 bbl. of pipe line oil per day through a ¼ and 7/64-in. choke. It was drilled to a depth of 11,618 ft.

The second discovery well is Magnolia's No. 1 M. J. Witzki, in the northwest quarter of 22-6s-11w, 2 miles southwest of the Oretta pool. On a drillstem test in perforations from 8422-26 ft. it flowed an estimated 75 to 100 bbl. of pipe line oil a day through a ¼-in. and 7/64-in. tubing choke.

Union of California No. 1 Milliken and Farwell, 26-12s-20e, is a prospective pool opener on the Hahnville prospect in St. Charles Parish. Reperforated from 8776 85 ft. the well flowed at the rate of 80 bbl. a day for 24 hr. and then went dead.

A new gas-condensate oil pool in Jefferson Parish has been opened by The Texas Company with its State Barataria Bay No. 1. The well flowed an estimated 95 bbl. of 55.8 gravity condensate with 1,080,000 cu. ft. of gas through casing perforations from 11,397 to 11,407 ft. The well has been drilled to 14,490 ft.

● **OKLAHOMA.** The Public Service Company of Oklahoma has a possible new oil pool with its Rose No. 1, C NW SE, 28-10-12e, in the Gregory gas area, east of Weleetka, in extreme eastern Okfuskee County. The well had the Gilcrease sand from 2355 to 2360 ft. After 5-in. casing was set at 2353 ft., the cement plug was drilled out and the well showed for 2,500,000 cu. ft. of gas and a spray of oil. Field men said the oil spray was estimated at 1 to 2 bbl. an hr.

A new Calvin sand area appeared to be opening with the J. W. Sorrels No. 1 Swan, in SW NE NE, 36-7n-5e, south of the Hazel pool of east-central Seminole County. In the producing formation from 2505 to 2550 ft. it was drilled in flowing 95 bbl. of oil through open tubing.

A possible new pool opener for Logan County is Sinclair-Prairie Oil Company No. 1 Teuscher, SE SE SW, 45-15n-1w. The Wilcox sand was found twice, first from 5882 to 5836 ft. and again from 5909 to 5923 ft.

Eastern Lincoln County may be the locale of a new pool opened at the R. H. Pierce No. 1 Hertz, SW SW SE, 7-15n-54, wildcat 2 miles from the town of Kendrick. The Prue sand was topped 3490 ft. and a 6-ft. core to bottom showed high porosity with strong oil odor. Total depth was 3502 ft.

Globe Oil and Refining Company wildcat, Davis and Patterson No. 1, SW SW NW, 22-9n-7e, appears to be the first oil discovery for Oklahoma in 1946. The discovery well is several miles due south of the most southerly well in the Cheyarha (Hills and Dale) pool of Seminole County. It produced 7 to 10 bbl. of oil an hr., along with an ungaged volume of gas from the Cromwell sand. Total depth is 3450 ft.

Another new discovery well loomed in the old Greater Seminole field area with the Skelly Oil Company No. 1 Price, SW NE NW, 26-8n-10e, east of the old Yeager pool and south of the Wetumka area, all in northeastern Hughes County. A drillstem test was taken from 3325 to 3360 ft., opened 10 min. it made an estimated 5,000,000 to 10,000,000 cu. ft. of gas and recovered 45 ft. of drilling mud. The Wapanucka lime was found at 3065 ft., the Union Valley lime at 3320 ft., and the top of the Cromwell sand at 3357 ft.

● **CALIFORNIA.** There is apparently a new dry gas field in northern California, found by Shell Oil Company No. 1 McCune in the Winters area 25 miles from Sacramento. The well blew in at a rated 6,300,000 cu. ft. of gas daily at 5209-34 ft.

● **TEXAS.** Starr County has a new oil pool in the Frio at Baldridge and King No. 1 A. Guerra, in the La Reforma area near the corner where Starr and Hidalgo counties meet. The well has been shut in pending construction of storage tanks and has not been gaged.

There is possibility of a new Ellenburger lime pool in Wichita County, north of Electra. The well is National Associated Petroleum No. 1 Willie Proud, block 189, Waggoner Colony lands. It was drilled to a total depth of 4925 ft. The hole filled with fluid, 90 per cent oil, the balance drilling mud.

An old dump ground proved very profitable when it was discovered that an oil pool was lying beneath it. Roeser and Pendleton-Continental Oil Company No. 2-42 Cook estate near the center of section 84. ETRR survey, Shackleford County, came in pumping 26 bbl. of oil daily from 1405-09 ft. to open a new Cook sand pool.

The Hanlon-Buchanan, Inc., and Ben Rankin No. 1 Mary Logan, J. Poitevent survey, abstract 228, opens a new Caddo lime field for Young County. The well has been completed to flow 81.26 bbl. of 41 gravity oil daily, with gas-oil ratio of 1700 to 1. Total depth is 4012 ft.

A new pool opener for North Texas is indicated by the National Associated Petroleum Company, J. E. Crosbie, Inc., and Warren Petroleum Corporation, No. 1 Proug, NW NE of block 189, Waggoner-Colony sub-division of Wichita County. Drilled to total depth of 4526 ft., the wildcat had the top of the Ellenburger lower Ordivician at 4496 ft. Pipe was set to 4501 ft. and the cement plug was drilled to total depth to get a fill up of oil and mud. The crew bailed out mud and the volume of oil and gas increased.

A new Permian lime area appeared to be opening with the Skelly Oil Company No. 1-Z University, in 10-11-U, 1½ miles west of the West Andrews pool of Andrews County, West Texas. Started as a 10,000-ft. wildcat a drillstem test was made of the San Andres lime of the upper Permian from 4209 to 4400 ft. and recovered 120 ft. of gas-cut drilling mud with slight traces of oil. After being drilled to 4430 ft. another drillstem test was run from 4376 to 4430 ft. and in an hour recovered 90 ft. of heavy oil and gas cut drilling mud.

South Texas has a new Edwards lime field in Atascosa County. The discovery well is the Quintana Petroleum (H. R. Cullen, Houston) No. 1 Muil. It is flowing an ungaged volume of oil and gas and the total depth is 9105 ft.

There are indications of a new Travis Peak sand oil pool for Harrison County. The well is the R. W. Williams No. 1 Furrh Estate, Frances O'Neal survey. Commercial production was indicated on a 10-min. drillstem test from 6290 to 6305 ft. with recovery of 1440-ft. water cushion and 2 to 3 gal. of 40 to 45-gravity light green oil.

Fred M. Manning, Inc., opened a new Strawn sand pool in Archer County, North Texas, with its Ford No. 1-A, between the Nichols and Browning, Ellenburger, lower Ordovician, lime pools. The discovery was completed to flow an estimated 150 bbl. of 42-gravity oil in 24 hr. from 4122 to 4161 ft.

● **KANSAS.** An apparent new natural gas discovery well for the Sun City-Hargin area is the Drillers Gas Company No. 2-B Skinner, in SW NE NE of 2-31-14. Production of 39,900,000 cu. ft. initially was from the Maquota dolomite. Total depth is 4380 ft.

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EXAMPLE: Well No. 8642

Drilled 1938. Initial potential—58 barrels per day after acidizing. Production finally dropped to 3 barrels oil and ½ barrel water per day. Permeability survey followed by Selective Acidizing with Electric Pilot restored production to 40 barrels per day.

Look to

FOR OIL INDUSTRY CHEMICAL SERVICE

MAJOR *Pipe Line* ACTIVITIES

● **NEW OUTLET.** A 30-mile 8-in. pipe line will be constructed by the White Eagle division of Socony-Vacuum Oil Company from a connection with the Kaw Pipe Line Company near Bemis field of Ellis County, to the Morris pool of Graham County, all in western Kansas. It will allow the White Eagle to procure an additional 18,000 bbl. of crude oil now waiting for a market.

● **RECORD COMPLETION TIME.** In a record 7 months' time the Panhandle Eastern Pipe Line Company, of Kansas City, completed an improvement program costing substantially more than ten million dollars. The program called for the installation of 33 new compressor units aggregating 32,800 hp., the laying of 31 miles of 24-in. pipe line, and other improvements. With the new equipment the company will be able to pump an additional 150,000,000 cu. ft. of gas daily from Texas to Ohio, West Virginia, eastern Indiana, and lower Michigan, bringing its daily capacity up to 380,000,000 cu. ft.

Every possible shortcut that could be taken to insure completion of the improvement by December 1 was used, which included the planning of engineering work that was well advanced prior to the beginning of actual construction, the setting up of batch mixing plants to pour large quantities of concrete in the shortest possible time, the renting of heavy mechanical equipment for all excavating work and for the erection of necessary steel structures, the installation of duplicate traveling cranes to facilitate engine erection, the use of air wrenches and other power driven tools, and the purchase of prefabricated pipe to the exclusion of field fabrication.

The construction work was done by the following companies: The Cooper-Bessemer Corporation, Mount Vernon, Ohio, and Grove City, Pennsylvania; The J. F. Pritchard Company, Kansas City, Missouri; The Fluor Corporation, Los Angeles, California, and Midwestern Engineers, Tulsa, Oklahoma.

● **GUARD "INCHES."** The Williams Brothers Corporation of Tulsa, Oklahoma, has been appointed custodian of the Big Inch and Little Inch pipe lines. War Emergency Pipelines, Inc., went out of existence January 31 and Williams Brothers took over the maintenance and protection of the wartime oil transportation lines on February 1. The company will be in charge of the lines until some disposal action is taken by Uncle Sam.

● **TARIFF RATES.** Now in service is the Great Lakes Pipe Line Company's new pipe line extension from Omaha to Sioux City, Iowa, and Sioux Falls, South Dakota. The company has published tariffs for movement of refined petroleum products to its two new terminals at Sioux City and Sioux Falls.

The tariffs are: From Oklahoma-Kansas to Sioux City, on gasoline and distillate fuel, 48 cents a bbl.; from Oklahoma-Kansas to Sioux Falls, 53 cents a bbl.

● **2-WAY RADIO OPERATES LINE.** A 2-way radio telephone network is being used by the United Gas Pipe Line Company for the operation of its 24-in. gas pipe line from Panola County, East Texas, to Sterlington, Louisiana. The network is the first of its kind in the southwest and has been approved by the Federal Communications Commission. It consists of three central stations in Shreveport, and Sterlington, Louisiana, and also has 44 portable-mobile units on service cars and trucks.

● **STORAGE SPACE.** The Surplus Property Administration has approved a proposal of the army-navy petroleum board to store 2,000,000 bbl of 100-octane gasoline in the Baytown-Beaumont gathering line tankage of the Little Big Inch pipe line in Texas. The agreement was in order to alleviate a critical oil storage situation and extends until May 1 and indefinitely thereafter until some disposal is made of the line

● **AIRPLANE FOR LINE LEAKS.** Kaw Pipe Line Company, owned jointly by Texas, Cities Service, and Phillips, now uses an airplane to spot leaks in its crude oil pipe lines. This method has supplanted the old one of 8 men spending their full working time walking the main line between Logan and Lyons, Kansas. Three times a month the cub cruiser plane covers the entire thousand mile route of main and feeder lines in a maximum of 3 days. An official of the company said the airplane method is far superior to the former ground method because there was not enough time to cover the entire intricate feeder network connection with the main line. Aviation makes possible the inspection of every foot of it.

● **BURMA LINE SOLD.** The 900-mile pipe line across Burma has been sold as scrap to a New Delhi concern, the Indian Traders Corporation. The sale price has been disclosed officially as 350,000 rupees (approximately $105,000).

● **PIPE REMOVAL.** The Sinclair Refining Company has applied to the Texas Railroad Commission to remove a 57-mile 8-in. pipe line. The line extends from Martha field, Liberty County, Texas, to Pure Oil Company's refinery near Nederland, Jefferson County, Texas.

● **LINE APPROVED.** The American-owned Transarabian Pipe Line Company, owned jointly by Standard Oil Company of California and The Texas Company, has been granted a permit to construct a Saudi Arabian pipe line to cross Palestine territory by the British High Commission for Palestine, Gen. Sir Alan Cunningham. The concession is an outcome of the Anglo-American oil agreement signed in London last September that provided for equal facilities for the signing nations in the Middle East.

The pipe line, if and when constructed, will extend from the Persian Gulf across Arabia and to Palestine, a total length of more than 1000 miles. It is planned to lay a pipe 24 in. in diameter with an annual capacity of 15,000,000 tons.

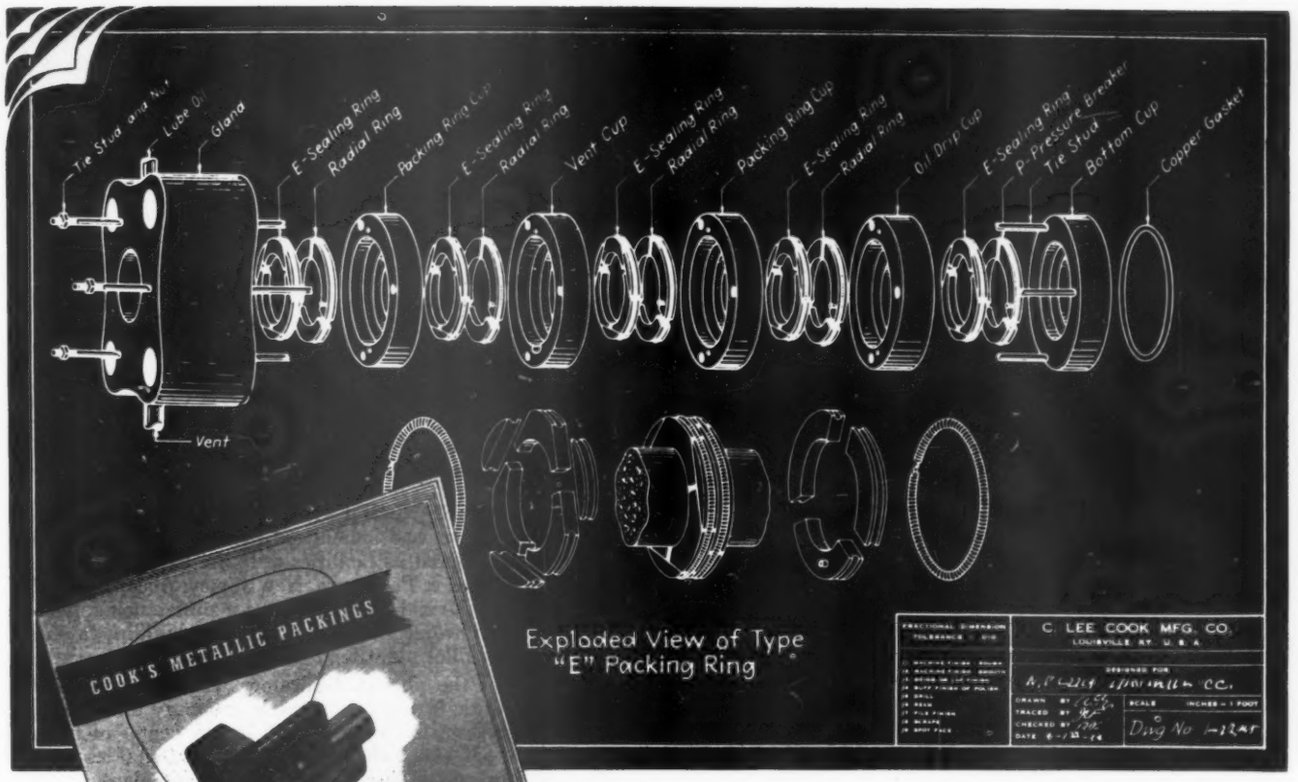
● **COMPLETING LINE.** Forty-seven miles of natural gas gathering lines in the Guymon field are being completed by Skelly Oil Company. The lines range in size from 4 to 22 in. with a system capacity estimated at 80,000,000 cu. ft. daily

● **BUILD PIPE LINE.** The construction of a 24-in. pipe line across Meade County, Kansas, will be started about June 1, by Northern Natural Gas Company, according to Al During, district manager. The new line will parallel the present one and will extend 84 miles from Old Springfield, in northern Seward County, Kansas, to Mullinville, Kansas. The line will be used for moving additional gas and will also be used for gas storage, if necessary.

● **CONSTRUCTION BEGUN.** The Texas-New Mexico Pipe Line Company has begun construction work on its 34 miles of 6-in. line to serve the Fort Stockton oil field, Pecos County. It connects with the company's main line at the Abell field station in the north central part of that county. Fredell Construction Company has the contract.

● **PENNSYLVANIA LINES COMPLETED.** Three short gas lines in Pennsylvania totaling 34,826 ft. have been completed by the United Natural Gas Company. One project consisted of 4796 ft. of 8-in. pipe from Heath Station, Jefferson County, to an existing 6-in. line in the same township. Another line consisted of 12,691 ft. of 8-in. pipe from Heath Station to an existing line in the Heath township, and the third was 17,339 ft. of 8-in. pipe from Spring Creek township, Elk County, to an existing line near Millstone. Anderson Brothers, Houston, Texas, was the contractor.

● **INCREASE LINE CAPACITY.** By using 2 additional pumping units at Gladewater station, Texas, Humble Pipe Line Company has increased the capacity of its 10-in. trunk line in East Texas from 27,500 bbl. to 32,700 bbl. a day. This line transports crude oil from the Hawkins and Sand Flat low-gravity fields.



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MAJOR *Refining* ACTIVITIES

● **BREAKS RECORDS.** Tide Water Associated Oil Company's catalytic unit No. 8 at its Bayonne, New Jersey, refinery has established two world records for the continuous operation of thermofor catalytic cracking units. The unit operated at full capacity for 240 days without a shut-down for its initial run. This surpassed the record of 217 days for any previous run by a thermofor catalytic cracking unit, according to officials of the company. At the same time it broke the preceding world's record for an initial run of 146 days.

The run is even more remarkable when it is considered that the Bayonne unit is totally dependent upon integral gas equipment to handle the gas produced and any shutdown of this equipment would have shut down the TCC unit. Only 8 days were required for complete turnaround at the end of this record breaking run.

● **MODERNIZE REFINERY.** Imperial Oil Limited, an affiliate of Standard of New Jersey, has announced plans to modernize and expand its refinery at Toronto, Canada.

The building of Canada's first catalytic cracking plant will be one of the most important faetures of the new program. The structure will be equal to a 15-story building in height and will incorporate the fluid catalyst method of cracking. Other construction work will include a 4200 bbl. per day catalytic polymerization plant and remodeling of existing equipment. Work is expected to begin this spring.

● **NAVY RETURNS REFINERIES.** The Socony-Vacuum Oil Company refinery at Augusta, Kansas, was returned to its owners by the Navy on January 27. The plant was seized by the Navy last fall on account of a wage dispute that has been settled by collective bargaining.

On January 24 the Cities Service Oil Company's refinery at Linden, New Jersey, was also returned by the Navy after settlement of a wage dispute. The Navy still is in control of Cities Service's large East Chicago, Indiana, refinery.

● **PLANT DISPOSAL.** It is the view of the Surplus Property Administration that the disposal of government-owned aviation gasoline plants and facilities to private interests presents seemingly no problem of monopoly because, despite the preponderance of refining capacity in 18 integrated companies, no single company with its affiliates controls more than 12 per cent of the total crude capacity or 13 per cent of the catalytic cracking capacity.

SPA states that the majority of the 29 federally owned plants likely will be disposed of to independent lessee-operators or other small refiners in the industry. The major problem in disposal to small operators is the fact that no basic refinery having a crude charge capacity of less than 5000 bbl. a day is adequate without additional supplies of gas oil or added crude capacity to support a catalytic cracking, alkylation, or isomerization unit.

SPA's report to Congress pointed out 3 sources to assist the small operator in meeting the competition of higher-quality fuels: (1) Progress in research indicates that the catalytic cracking process may soon be available for 3000 bbl-a-day refiners; (2) by procuring "cat" cracked blending material from other refiners to improve the quality of fuels produced by him, and (3) by joining with other small refiners to purchase and operate one of the government-owned plants.

● **TO BUILD PLANT.** Carthage Hydrocol, Inc., New York, plans to build a plant to manufacture gasoline from natural gas near Brownsville, Texas, at a cost of approximately $14,000,000. One-half of the cost will be financed by a loan from the Reconstruction Finance Corporation. Sale of units of stock should obtain the balance.

United Gas Corporation, Shreveport, Louisiana, has asked the Securities and Exchange Commission to approve its proposed acquisition of some stock in the Hydrocol company. United said it would benefit from Hydrocol's development of a process of manufacturing gasoline from natural gas because United Gas Pipe Line Company, which buys and sells natural gas, and Union Producing Company, owner of gas reserves in Louisiana, Texas, and other southwestern states, are subsidiaries of United Gas Corporation.

In the opinion of United engineers the process of manufacturing gasoline from natural gas "can possibly result in an important new and expanding market for natural gas when the process is further studied and developed on a commercial basis."

● **PLANT CLOSES.** Wilcox Oil and Gas Company's refinery at Bristow, Oklahoma, has closed because of inadequate storage facilities. Sales are continuing as usual and field operations of the company are not affected.

● **EXPAND RESEARCH FACILITIES.** The Socony-Vacuum Oil Company, Inc., has announced that it will construct new buildings and expand its facilities at its Research and Development Laboratories in Paulsboro, New Jersey. According to Wilbur F. Burt, vice president in charge of manufacturing, the foremost among the projects will be a chemistry building, a physics building, and a pilot plant for lubricating oils.

A section of the physics laboratory will be turned over to exploratory work in the use of nuclear energy and electronic devices. The chemistry building will be the center of research in the field of petroleum chemistry and fundamental research on fuels and lubricants. The lubricating oil pilot plant will have the latest in refining techniques and equipment such as distillation, solvent refining, and dewaxing processes. All types of improved motor and industrial lubricants will be produced in the plant.

Other fields in which research will be expanded as a result of the new construction will be in gas turbines, airplane, automobile, diesel, and marine engines.

● **REFINERY BURNS.** The Midwest Refineries, Findlay, Ohio, is mostly in ruins after a fire that set off a series of storage tank explosions. The superintendent of the refinery plant estimated the damage at $200,000 and said that 11 storage tanks containing gasoline, kerosine, oil, and asphalt blew up in the blaze.

● **AID TO CHINA.** Under terms of an agreement with China's National Resources Commission, Universal Oil Products Company will help China establish and develop a modern petroleum refining industry according to a company announcement. Possibilities for large-scale production of both crude and refined oil products in the Yumen field on the southern edge of the Gobi Desert, now turning out 4000 bbl. a day from 25 wells, will be investigated by Dr. Gustav Egloff and W. B. Shanley, Universal engineers, the company said.

● **RETURN TO OPERATION.** The plants at Cody and Riverton, Wyoming, belonging to Husky Refining Company of Cody have resumed operations and are processing 14,000 bbl. of crude oil a day, according to Glenn Nielson, president of the company. The plants will be operated from 3 to 6 months on a Navy contract.

● **PLANT EXPANSION.** Shell Oil Company, Inc., is making progress in improvements at its refinery in Deer Park, Texas. According to A. J. Galloway, vice president, the estimated cost will approximate $8,000,000.

The major construction project is a new fluid catalytic and absorption plant that was begun last summer. Reported the largest unit of its kind in Texas, it will process 25,000 bbl. or more of oil a day. The capacity of the power generating equipment of the refinery is being increased from 5000 to 25,000 kw. through installation of two 10,000-kw. non-condensing turbine generators, 3 integral furnace boilers, and one 625,000-lb.-per-hr. hot process lime gypsum water treater. These new installations are expected to be in operation early in 1947.

THE Petroleum Engineer

FEBRUARY, 1946

COST OF DISCOVERING NEW PETROLEUM RESERVES CONTINUED TO INCREASE IN 1945

By **H. J. STRUTH,** *Petroleum Economist*

EXCLUSIVE

New petroleum reserve discoveries in 1945, as measured by oil found in new fields, extensions to previously discovered producing areas and upward revisions in previous estimates, aggregated about 2,180,000,000 bbl. This was a net gain over initial reserve discoveries accounted for in 1944 of about 113,000,000 bbl.

Production of crude oil last year reached an all-time high of 1,706,000,000 bbl. Exploratory operations, represented by wildcat discovery wells and all dry holes, also attained a new all-time high level of 10,529. Reserve discoveries exceeded productive requirements by 474,000,000 bbl. Exploratory drilling operations topped those of 1944 by 2,772 drill-holes.

While 1945 appeared to be a better than average year, in the light of the foregoing factors, analysis reveals the fact that a substantial share of last year's oil discoveries were the result of earlier exploratory effort. In fact, 60 per cent of the oil found in 1945 was credited to discoveries made in previous years. New discoveries actually credited to last year's exploratory effort were in the order of about 875,000,000 bbl. Thus, the oil industry actually discovered about 32,000,000 bbl. less new oil than in 1944 and failed to meet productive requirements to the extent of approximately 831,000,000 bbl.

Under the impetus of the war effort, the American oil industry met a prescribed quota by drilling 27,045 wells during 1945. These included 4,105 wildcat operations and 6,424 development dry holes. The latter, aggregating 10,529 drill-holes, serve as an index of the industry's effort to discover new fields and to extend the boundaries of previously discovered producing areas. A particularly unfavorable aspect of the 1945 drilling program was the fact that failures to find oil or gas were 38 per cent greater than in 1944. Dry holes constituted 36 per cent of all the wells drilled in 1945, compared with an average of 31 per cent in 1944 and an average of 22 per cent in the five years ending with 1940.

In the last 5 years—	
Exploration increased	41%
Results off	58%
Costs increased	256%

The cost of discovering new petroleum reserves continued to increase in 1945. Between 1936 and 1940 the cost of finding oil, including all subsequent extensions and revisions, was about 10.5 cents per bbl. Initial finding costs in 1945, excluding future extensions and revisions, mounted to a new high level of 63.4 cents per bbl. Assuming, by past experience, that discoveries made last year may be expected to yield greater ultimate recoverable reserves, due to subsequent extensions and revisions in first estimates, the writer has projected the trend of such additions. Consequently, the revised cost of finding oil in 1945 has been placed at an average of 49.6 cents per bbl. This represents an increase in finding or replacement cost of 39.1 cents per bbl. over the previous average cost of 10.5 cents per bbl.

Economic justification of oil producers' pleas for higher crude oil prices is forcefully demonstrated by these facts. Without considering other cost factors, such as development of new pools and the cost of producing crude oil, the increases that have had to be absorbed by producers in the cost of finding oil are sufficient evidence of the need for an immediate advance in crude prices. In the last five years, the initial cost of finding oil has increased 35 cents per bbl. over the preceding 5-year period. On a deferred basis, namely, waiting several years to determine ultimate reserve discoveries, the cost over the same period has increased 27 cents per bbl. Even if no consideration is given to the increased costs incurred in the development of new oil pools, or the increased cost of producing oil from proven fields, the present price of crude oil is below bare economic existence levels by somewhere between 27 and 35 cents per bbl.

The plight of the American oil producer may be summed up in a few significant factual statements. In the last five years the facts prove that his effort has increased 41 per cent, despite adverse conditions; the results of that effort have shown a decrease of 58 per cent; his costs have meanwhile increased 256 per cent! Those who have been instrumental in throttling the oil industry by refusing to lift the unreasonable, subnormal price ceilings imposed upon crude oil may well give careful consideration to these facts. The results of exploration in the past four years exemplify the folly of continuing to ignore the unvarnished economic truths concerning the crude oil price situation.

Deeper drilling, substantially higher labor costs, increased cost of materials

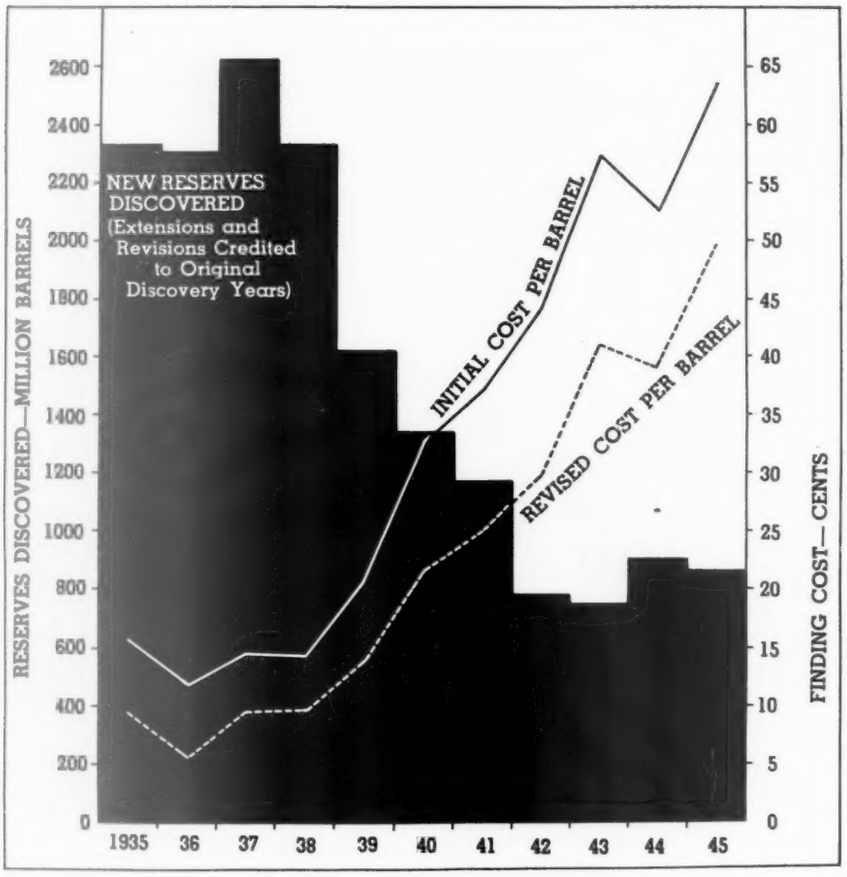


FIG. 1. ECONOMICS DICTATE HIGHER CRUDE PRICES. Initial finding cost of new petroleum reserves discovered in the last five years averaged 35 cents more per barrel than in the preceding five years.

and supplies and heavier state, local and federal taves have resulted in an increase in exploration expenditures of this industry amounting to more than $168,000,000 during 1945. The cost of drilling exploratory wells, including all dry holes, was $352,397,000. Additional costs incurred through the acquisition and carrying of leases, geological and geophysical expense and overhead costs amounted to $368,850,000.

The total cost of exploratory operations in 1945 is estimated by the writer at $721,247,000, compared with a total of $553,226,000 in the year 1944. The preliminary exploration expenditure figures for 1945 are detailed at right.

The average cost of exploration per well drilled last year was $68,500, compared with an average of $71,319 per well in 1944. The reduction in cost last year was due to the fact that a larger proportion of the wells drilled were dry holes, which usually average from one-half to two-thirds of the cost of a completed producer. The industry drilled 2,709 more dry holes last year than in 1944, while the dry hole hazard was about five per cent greater than in the preceding year.

Fig. 1 shows what has happened to new reserve discoveries over the last 11 years and the effect of diminishing rates of discovery of new reserves upon the unit cost of finding oil. The figures upon which this chart is based are presented in Table 1. Initial oil finding costs per barrel represent the cost of reserves originally calculated, before subsequent revisions. In computing finding costs per barrel, all reserves found during the year, including new fields and extensions to previously discovered fields, must be used as a divisor. These figures are subject to revisions over a period of several years, which in turn reduces or increases the final cost of discoveries.

Revised finding costs per barrel represent the re-appraised cost after allocations of subsequent revisions. In order to reflect the deferred effect of subsequent additions to initial 1945 discoveries, the costs have been projected on a revised basis to include expected subsequent revisions. Comparatively, the adjusted cost of finding oil in 1945 is about 10.6 cents higher per barrel than the revised cost in 1944.

Last year, the writer made similar calculations and arrived at an adjusted average cost for 1944 of 41.3 cents per barrel. Revisions in these early estimates have reduced the cost to 39 cents per barrel. It is likely that future revisions for fields discovered last year will effect a slightly lower average cost than the figure computed herein by preliminary estimates and projections.

A paramount factor in the search for and discovery of oil reserves to provide a back-log for future needs is the cost of replacing oil withdrawn from the underground reservoirs. Replacement costs have reached a critical stage and the facts revealed here make it evident that a compensatory upward revision in crude oil prices is imperative to the best interests of the nation as well as the petroleum

U. S. EXPLORATION EXPENDITURES
1945

Drilling and equipping exploratory wells	**$352,397,000**
Cost of acquiring and carrying leases, including land departments	**245,500,000**
Geological and geophysical cost	**65,450,000**
Overhead and general office expense	**57,900,000**
Grand total	**$721,247,000**

TABLE 1
Approximate cost of finding oil in the United States.

(Barrels in millions—money in thousands)
(Revised 1945)

Year	Initial reserves discovered (a)	Working Interest (85.5%) (b)	Revised reserves discovered (c)	Working interest (85.5%) (d)	Exploratory wells drilled (e)	Total drilling cost (f)	Lease & overhead cost (g)	Total cost (h)	Initial cost per bbl. (h÷d)	Revised cost per bbl. (h÷d)	Average expenditure per well (h÷e)
1935	1,220	1,043	2,050	1,753	5,231	$ 57,639	$104,620	$162,259	15.5	9.3	$31,000
1936	1,763	1,507	3,770	3,223	5,671	63,414	113,420	176,834	11.9	5.6	31,200
1937	1,929	1,649	2,975	2,544	6,900	85,320	151,800	237,120	14.3	9.3	34,400
1938	1,854	1,585	2,710	2,317	6,453	81,750	141,966	223,716	14.1	9.7	34,700
1939	1,450	1,240	2,111	1,805	6,732	90,177	161,568	251,745	20.3	13.9	37,400
1940	1,020	872	1,536	1,313	7,032	102,644	182,832	285,476	32.7	21.7	40,600
1941	980	838	1,455	1,244	7,388	125,075	185,221	310,296	37.0	24.9	42,000
1942	779	666	1,160	992	6,123	121,302	172,602	293,904	44.1	29.6	48,000
1943	862	737	1,202	1,028	6,703	169,222	252,140	421,362	57.1	41.0	62,862
1944	1,231	1,052	1,661	1,420	7,757	246,516	294,983	553,226	52.6	39.0	71,319
1945*	1,330	1,137	1,700(u)	1,453	10,529	352,397	368,850	721,247	63.4	49.6(s)	68,500

*Preliminary—subject to final revision.
(a) New field discoveries and extensions to previously discovered fields.
(c) Includes subsequent revisions in first estimates.
(e) Wildcat producers and all dry holes drilled in exploration and development.
(f) Costs include equipping wildcat producers.
(g) Includes cost of leases, geological, geophysical expense and overhead costs.
(s) Projected to include effect of subsequent upward revisions in first estimates.
(u) Provides for subsequent upward revisions aggregating about 370 million barrels.

TABLE 2

Replacement cost of reserves.

(Revised 1945)

Year	New reserves discovered (million) △	Crude oil produced (million)	Surplus or short (million)	Working interest (85.5%) (million)	Adjusted finding cost per bbl.	Total finding cost (thousands)
1935	2,325	997	+1,328	+1,133	$ .093	$105,369
1936	2,305	1,100	+1,205	+1,030	.056	57,680
1937	2,629	1,278	+1,351	+1,155	.093	107,415
1938	2,330	1,213	+1,117	+ 955	.097	92,635
1939	1,616	1,264	+ 352	+ 301	.139	41,839
Total—Period of surplus	11,255	5,852	+5,353	+4,577	.088	$404,938
1940	1,336	1,352	— 16	— 14	.217	3,038
1941	1,165	1,404	— 239	— 204	.249	50,796
1942	775	1,385	— 610	— 522	.296	154,512
1943	752	1,503	— 751	— 642	.410	263,220
1944	907	1,678	— 771	— 659	.390	257,010
1945	875	1,706	— 831	— 710	.496*	352,160
Future to balance			—2,135	—1,826	.496*	905,696
Total—Period of shortage	(5,810)**	(9,028)**	—5,353	—4,577	.434	$1,986,432

△Extensions and revisions credited to original discovery years.

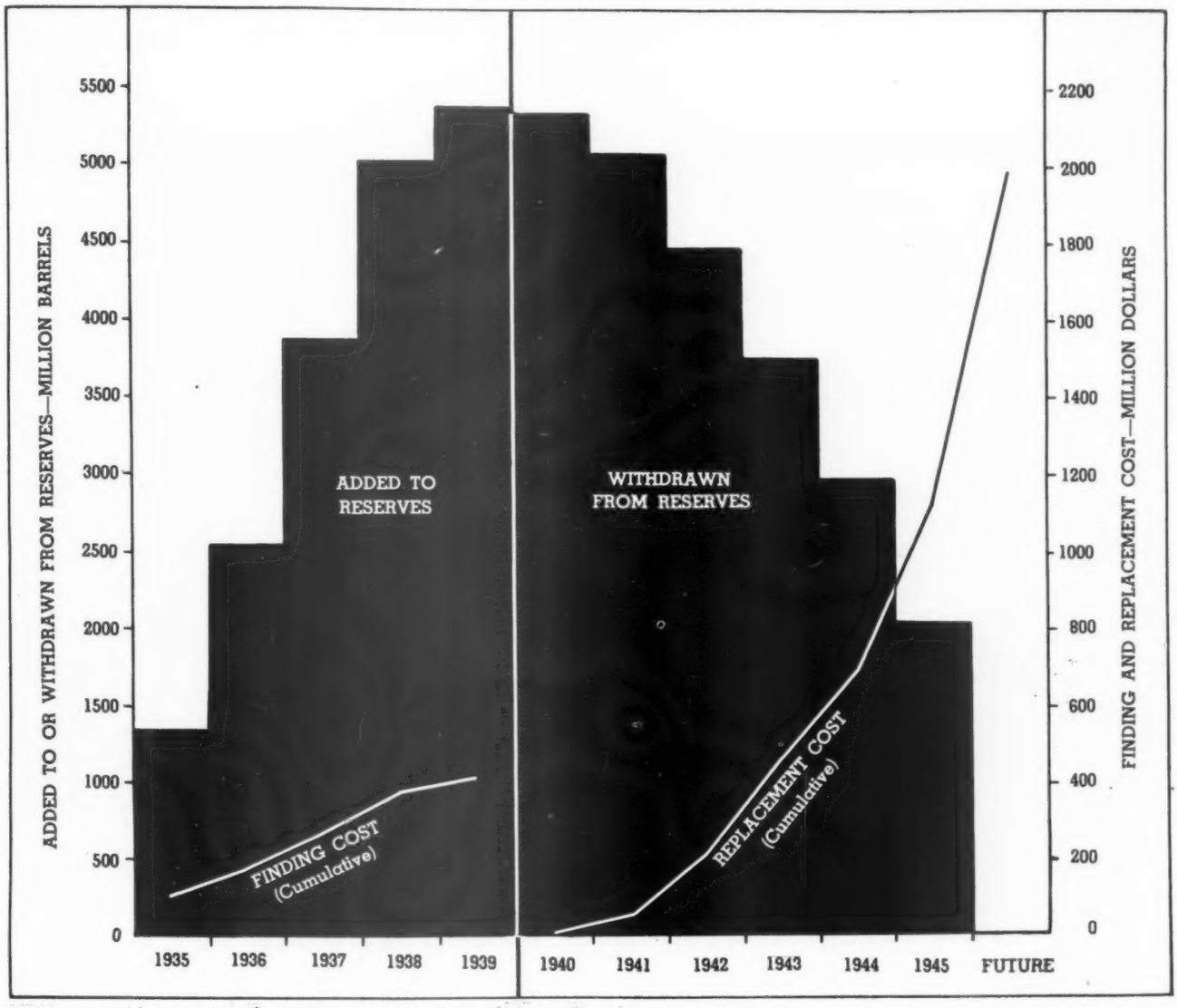
*Based upon assumption of future upward revisions in initial estimates of reserve discoveries. Initial cost in 1945 was 63.4 cents per barrel.

**Totals through 1945 only.

TABLE 3—Analysis of crude oil reserve replacement cost.

Period 1935-39:	
Net reserves added by discoveries, bbl.	5,353,000,000
Working interest (85.5%), bbl.	4,577,000,000
Average finding cost per bbl.	$ .088
Total finding cost	$ 404,938,000
Period 1940-45:	
Net reserves withdrawn to meet demand above discoveries, bbl.	3,218,000,000
Working interest (85.5%), bbl.	2,751,000,000
Average finding cost per bbl.	$ .390
Total cost of oil replaced	$1,080,736,000
Future replacement of reserves:	
Reserves to be replaced to balance discoveries during 1935-39, bbl.	2,135,000,000
Working interest (85.5%), bbl.	1,826,000,000
Adjusted finding cost per bbl. (1945)	$ .496
Total replacement cost	$ 905,696,000
Summary of results:	
Total cost of replacing 1935-39 reserve additions	$1,986,432,000
Less 1935-39 finding cost	404,938,000
Net replacement cost	$1,581,494,000
Net replacement cost per bbl.	$ .346

FIG. 2. FINDING AND REPLACEMENT COST OF RESERVES. For every dollar spent finding oil before the war, the industry must now spend $4.90 in replacement costs.



industry. Fig. 2 shows the degree to which replacement costs have mounted since 1940.

Analyses of finding and replacement costs of reserves are presented in Tables 2 and 3. The long-fought contention of producers that an advance of 35 cents per

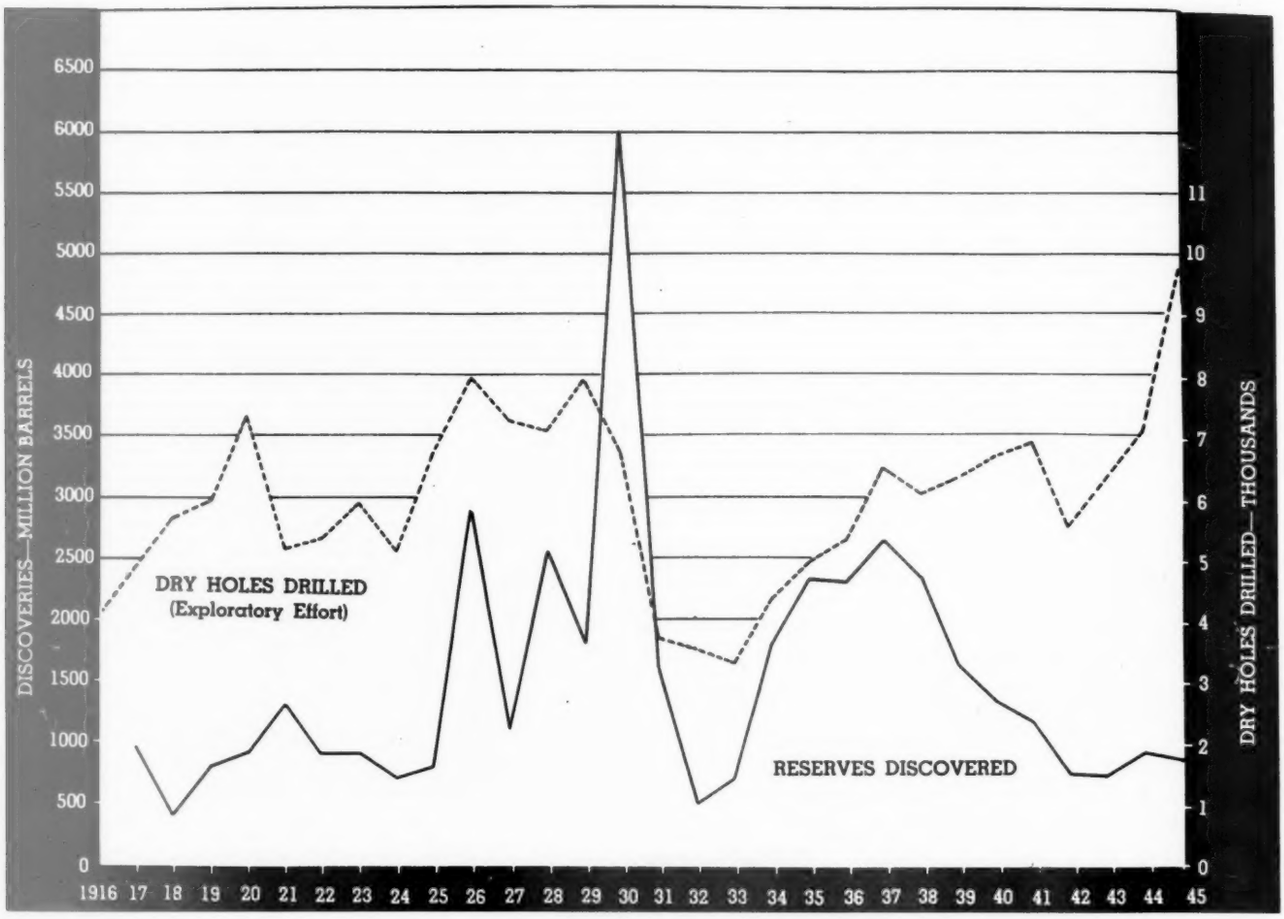


FIG. 3. RESERVES DISCOVERED AND EXPLORATORY EFFORT. The inventory of underground reserves turned downward in 1939. Since then, the effort to find oil, as measured by the number of dry holes drilled, has ascended to an all-time high.

barrel is necessary to offset increased costs, is sustained by the facts, which reveal a net increase in replacement costs of 34.6 cents per barrel.

Except for a moderate increase in reserve discoveries in 1944, the trend of oil finding has been downward since 1937. In fact, new oil discoveries of the last 5 years dropped 56 per cent below the annual average of the preceding 5 years. Meanwhile, under the impetus of war, the oil industry concentrated its efforts on wildcat drilling and chalked up the largest dry hole ratios in its history.

Fig. 3, showing reserve discoveries and dry holes drilled over the last 30 years, has been completely revised to include all allocations of extensions and revsions to years of original discovery. Table 4 contains the detailed figures and also includes data to show the relationship of reserve discoveries to production, dry holes per million barrels of oil found and estimates of underground reserves.

Highly significant are the ratios of dry holes drilled per million barrels of new oil found. In 1945, the industry had to drill 11 dry holes to lead to the discovery of a million barrels of new reserves. This is compared with a ratio of 2 dry holes per million in 1937 and only 1 dry hole

TABLE 4—Dry holes, reserves discovered, production.
(1916-45 Inclusive) (All barrels are in millions)

Year	Dry holes drilled	New reserves discovered[Δ]	Dry holes per million bbl.	Annual crude production	Surplus or short	Reported reserve inventory	Adjusted reserve inventory
1916	4,039	250	16	301	— 51	5,900	5,242
1917	4,851	950	5	335	+ 615	5,900	5,857
1918	5,631	400	14	356	+ 44	6,200	5,901
1919	5,986	800	7	378	+ 422	6,700	6,323
1920	7,346	900	8	443	+ 457	7,200	6,780
Total 5 years	27,853	3,300	..	1,813	+1487		
Annual average	5,571	660	8	363	+ 297		
1921	5,160	1,300	4	472	+ 828	7,800	7,608
1922	5,332	900	5	557	+ 343	7,600	7,951
1923	5,883	900	6	732	+ 168	7,600	8,119
1924	5,044	700	7	714	— 14	7,500	8,105
1925	6,734	800	8	764	+ 36	8,500	8,141
Total 5 years	28,153	4,600	..	3,239	+1361		
Annual average	5,631	920	6	648	+ 272		
1926	7,965	2,900	4	771	+2129	8,800	10,270
1927	7,210	1,100	6	901	+ 199	10,500	10,469
1928	7,078	2,550	3	901	+1649	11,000	12,118
1929	7,914	1,800	4	1,007	+ 793	13,200	12,911
1930	6,734	6,000	1	898	+5102	13,600	18,013
Total 5 years	36,901	14,350	..	4,478	+9872		
Annual average	7,380	2,870	2	896	+1974		
1931	3,650	1,600	2	851	+ 749	13,000	18,762
1932	3,569	500	7	785	— 285	12,300	18,477
1933	3,312	700	5	906	— 206	12,000	18,271
1934	4,312	1,800	2	908	+ 892	12,177	19,171
1935	4,911	2,325	2	997	+1328	12,400	20,499
Total 5 years	19,763	6,925	..	4,447	+2478		
Annual average	3,953	1,385	2	889	+ 495		
1936	5,296	2,305	2	1,100	+1205	13,063	21,704
1937	6,420	2,629	2	1,278	+1351	15,507	23,055
1938	6,043	2,330	3	1,213	+1117	17,348	24,172
1939	6,357	1,616	4	1,264	+ 352	18,483	24,524
1940	6,617	1,336	5	1,352	— 16	19,025	24,508
Total 5 years	30,733	10,216	..	6,207	+4009		
Annual average	6,147	2,043	3	1,241	+ 802		
1941	6,885	1,165	6	1,404	— 239	19,589	24,269
1942	5,532	775	7	1,385	— 610	20,083	23,659
1943	6,266	752	8	1,503	— 751	20,064	22,908
1944	7,149	907	8	1,678	— 771	20,453	22,137
1945 (p)	9,858	875	11	1,706	— 831	20,928	21,306*
Total 5 years	35,690	4,474	..	7,676	—3202		
Annual average	7,138	895	8	1,535	— 640		

(p) Preliminary. [Δ]Extensions and revisions credited to years of original discovery.
*Includes allowance for upward revision in 1945 discoveries.

TABLE 5—Drilling and exploratory results, 1944-45.

	1945	1944	Per cent change
Wildcats:			
Oil wells (new discoveries)...	427	380	+12
Oil wells (extensions).....	114	113	+ 1
Gas wells.....	130	115	+13
Dry holes.....	3,434	3,240	+ 6
Total wildcats.....	4,105	3,848	+ 7
Development dry holes.....	6,424	3,909	+64
Total exploratory holes....	10,529	7,757	+36
Development oil wells.....	13,921	12,698	+10
Development gas wells.....	2,595	2,198	+18
Total wells drilled.....	27,045	22,653	+19
Discoveries:			
Oil wells completed.....	427	380	+12
New oil discovered (millions).	475	511	— 7
Average per well (thousands)	1,112	1,345	—17
Extensions*:			
Oil wells completed.....	114	113	+ 1
New oil discovered (millions).	855†	720	+19
Average per well (thousands)	7,500	6,372	+18
Composite (all wildcats):			
Oil wells completed.....	541	493	+10
New oil discovered (millions).	1,330	1,231	+ 8
Average per well (thousands)	2,458	2,497	— 2
Exploratory results:			
Exploratory wells drilled....	10,529	7,757	+36
New oil discovered (millions).	1,330	1,231	+ 8
Average per hole (thousands)	126	159	—21

*Revisions credited to original discovery years.
†Adjusted in anticipation of subsequent upward revision.

TABLE 6—Results of exploratory effort.
(Revised 1945)

Year	Exploratory wells drilled	Reserves discovered			Wells per million bbl.	Reserves found per exploratory well (thousands)
		New fields (millions)	Extensions and revisions (millions)	Total (millions)		
1935	5,231	950	1,100	2,050	2.55	392
1936	5,671	850	2,890	3,740	1.52	665
1937	6,900	929	2,046	2,975	2.32	431
1938	6,453	810	1,900	2,710	2.38	420
1939	6,732	341	1,770	2,111	3.19	314
1940	7,032	286	1,250	1,536	4.58	218
1941	7,388	430	1,025	1,455	5.08	197
1942	6,123	260	900	1,160	5.28	189
1943	6,703	282	920	1,202	5.58	179
1944(r)	7,757	511	1,150	1,661	4.67	214
1945(p)	10,529	475	1,225*	1,700	6.19	161

(r) Revised. (p) Preliminary.
*Provides for subsequent upward revisions.

per million barrels found in 1930. The latter year was the most successful one in the industry's history, the year East Texas was found.

Estimates of underground reserves indicate that the industry now has a proved, available future supply of crude oil of between 20,928,000,000 bbl. and 21,306,000,000 bbl. While this represents a substantial back-log, exclusive of tremendous potentialities known to be available through the nation's huge natural gas reserves, it is obvious that the constantly greater demand for petroleum products calls for an increasing ratio of discoveries to production. Prior to the last five or six years the ratio of discoveries to production, including subsequent extensions and revisions, has been about 1½ to 1. This ratio has been computed by eliminating the 5-year period ending in 1930, which included the discovery of East Texas. During the last 6 years, production aggregated 9,028,000,000 bbl., while net discoveries were 5,810,000,000 bbl. If a ratio of 1½ to 1 is desirable, discoveries during this period should have been about 13,500,000,000 bbl., or 7,700,000,000 bbl. more than was actually found.

Exploratory results for 1944 and 1945, using first estimates for both years, reveal a decline last year in discovery ratios of 21 per cent. Analysis of wildcat discoveries and extensions shows a drop of 17 per cent in initial discoveries per well, while extensions to fields previously discovered showed an increase in recovery per well of 18 per cent. (see Table 5.) The composite index for all wildcat oil producers was two per cent under the year 1944. Exploratory drilling, including development dry holes, increased 36 per cent over 1944. Attempts to extend previously discovered oil pools, reflected by the number of development dry holes drilled, showed an increase over 1944 of 64 per cent. It is significant also that 87 per cent of all wildcat wells drilled last year were dry holes.

Results of exploratory effort last year present a complex picture. While discoveries through new fields and extensions showed some improvement over 1944, it took 6.19 discovery wells to find a million barrels of new oil compared with 4.67 wells per million in 1944. While the cost per exploratory well was lower in 1945 than in the preceding year, due to the drilling of more dry holes, which are less costly than completed producers, the total cost per million barrels of oil found was nearly 30 per cent greater than in 1944. Fig. 4 shows the trend of discoveries and number of wells drilled per million barrels found, as well as the upward trend in expenditures per well. Table 6 shows the calculations and total expenditure per million barrels of gross oil discovered since 1935. Over the last 5 years, the industry had to spend over a billion dollars more in exploration costs and found only 54 per cent as much oil as in the preceding 5 years.

The oil industry drilled 5,100 more wildcat wells in the last 5 years but found 6,000,000,000 bbl. less than in the preceding 5-year period. Fig. 5 shows the trend of wildcat drilling since 1935 and the trend of discoveries per wildcat producer. In the last 5 years the index of reserves found per wildcat producer has declined to but 22 per cent of the ultimate recoveries per producer com-

FIG. 4. MORE WELLS, GREATER COST, LESS OIL FOUND. In the last five years although the oil industry drilled 6,000 more exploratory wells and spent three times as much to find oil, it found only 55 per cent as much as in the preceding five years.

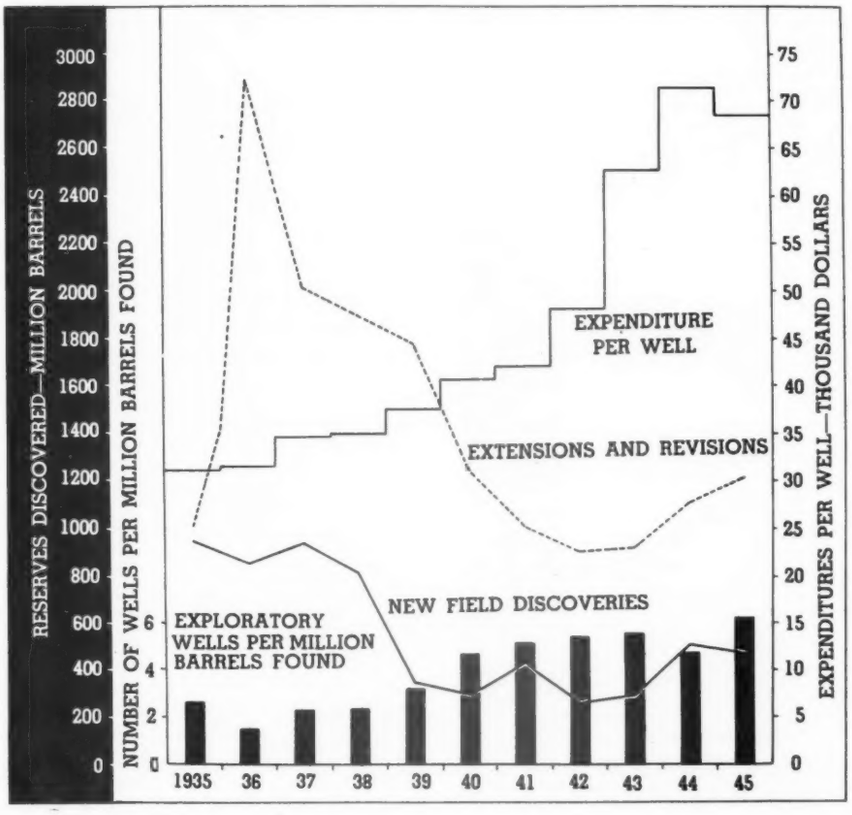

RESERVES DISCOVERED—MILLION BARRELS
NUMBER OF WELLS PER MILLION BARRELS FOUND
EXPENDITURES PER WELL—THOUSAND DOLLARS
EXPENDITURE PER WELL
EXTENSIONS AND REVISIONS
NEW FIELD DISCOVERIES
EXPLORATORY WELLS PER MILLION BARRELS FOUND
1935 36 37 38 39 40 41 42 43 44 45

TABLE 7—Wildcat wells and oil discoveries.
(Comparative data, 1935-45)

Year	Total wildcats drilled	Wildcat producers	Per cent Producers	Reserves found (millions)	Average per well	
					All wildcats (thousands)	Wildcat producers (thousands)
1935	1,675 (e)	190 (e)	11	2,325	1,388	12,237
1936	1,950 (e)	215 (e)	11	2,305	1,182	10,721
1937	2,224	250	11	2,629	1,182	10,516
1938	2,638	260	10	2,330	883	8,962
1939	2,589	245	9	1,616	624	6,596
1940	3,038	300	10	1,336	440	4,453
1941	3,264	504	15	1,165	357	2,312
1942	3,045	408	13	775	225	1,899
1943	3,319	432	13	752	227	1,741
1944	3,848	493	13	907	236	1,840
1945	4,105	541	13	875	213	1,617

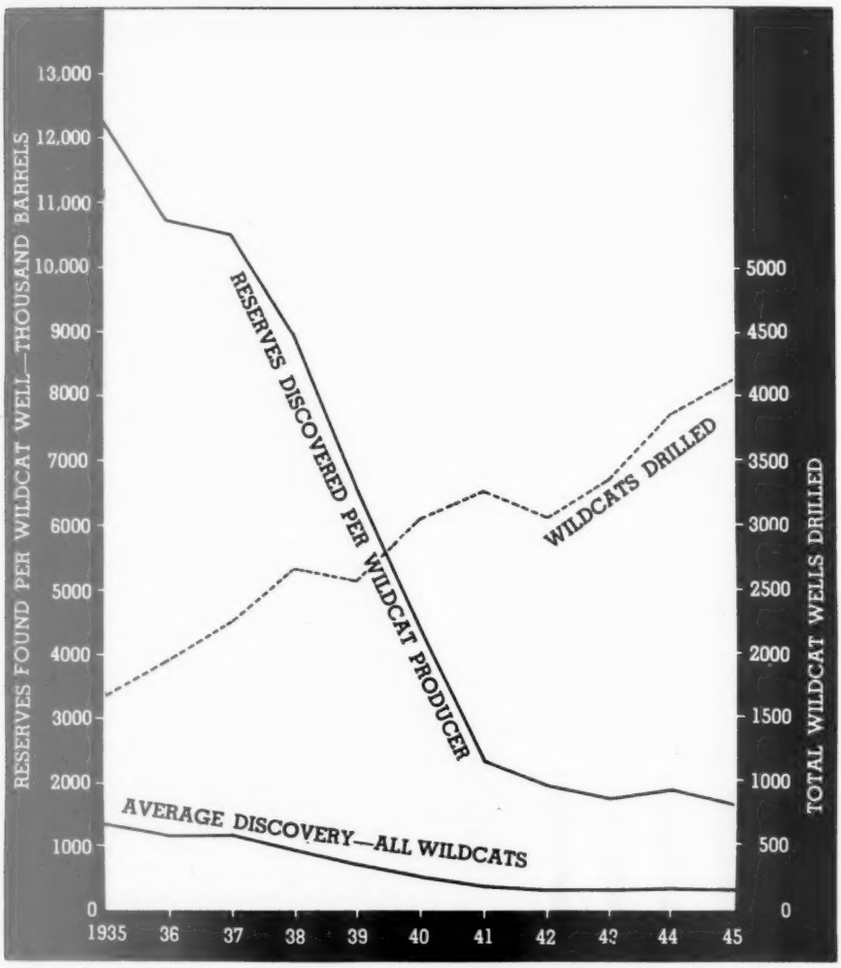
(e) Estimated.

TABLE 8—Reserve discoveries related to all drilling.
(All figures on an annual average basis)

Period	All wells drilled	Oil Wells completed	Reserves found* (millions)	Average found per well (all wells)	Average found per oil well
1916–20	27,359	19,732	660	24,124	33,448
1921–25	23,715	15,872	920	38,794	57,964
1926–30	24,678	14,634	2,870	116,298	196,118
1931–35	15,880	10,595	1,385	87,217	130,722
1936–40	27,589	19,107	2,043	74,051	106,924
1941–45	22,961	13,365	895	38,979	66,966

*Extensions and revisions credited to years of original discovery.

FIG. 5. EFFORT TO FIND OIL UP 41%; RESULTS OFF 58%. 5,100 more wildcats drilled in last 5 years, but discoveries were 6 billion barrels less than in preceding 5 years. Discoveries per successful wildcat were only 22 per cent as fruitful as in preceding 5 years.



pleted in the five years ending in 1940. A substantial share of this decline is attributed to war measures which called for greater concentration of effort in exploration for new sources of oil supply. Normally, greater attention would have been given by producers to extending the boundaries of previously discovered fields, which obviously bring greater rewards than drilling in unexplored areas.

Another index worthy of study is the average discovery of new oil reserves for all wells drilled and oil producers completed. Fig. 6 presents a picture of these relationships in 5-year periods since 1916. The facts show that the industry has consistently been discovering less oil per well drilled since the peak period of 1926-30. We think of 27,000 wells a year as being an extremely active period, but at the low discovery rates of the last 5 years it would seem to be in order for the industry to drill 50,000 wells a year! At least, that is how many wells it would take at current discovery rates to find 2,000,000,000 bbl. of new reserves.

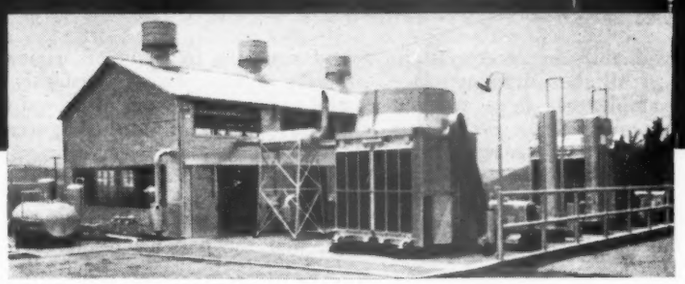
The data shown in Tables 7 and 8 present these facts on a comparative basis. Table 7 shows discovery rates per wildcat, while Table 8 relates discoveries with all wells drilled and oil wells completed. It is noteworthy that the average quantity of new reserves found per oil well completed has shown a precipitous decline since 1926-30, the period when East Texas was discovered. The startling fact is that discovery rates of the past 5 years have been at about the same level as that recorded between 1921-25. It is apparent, however, that the rate of discovery per oil well completed is about 15 per cent greater than in that earlier period. Considering productive requirements now experienced, as related to that of earlier years, it is evident that there is a deficit in discoveries of substantial proportions.

Despite these rather alarming conclusions, however, there are sound reasons for believing that the petroleum industry can and will meet any and all future requirements for crude oil and its products. This presumption is predicated upon the realization that most of the unfavorable conditions in the reserve picture were really brought about under abnormal war regulations and price controls, which have stifled individual effort and the normal exercise of experience and judgment. No one knows the oil business better than the oil men. Under proper incentives and freedom of action, the American oil industry may be relied upon to meet adequately all future requirements for petroleum and its products.

Many oil fields have been discovered in the past 5 years, which have not as yet been fully developed to determine their ultimate reserve potentialities. Many of these fields offer opportunities of extension and greater ultimate productivity. How soon these new areas will be developed depends largely upon how soon the price of crude oil is adjusted to its proper economic level. Fig. 7 shows that the bulk of the oil discoveries made in recent years have been credited to

Cooper-Bessemer

..FIRST CHOICE FOR MODERN OIL LINE PUMPING



The above engine, installed in a California crude oil pumping station, is a Cooper-Bessemer Type JS 8-cylinder gas engine rated 600 hp at 400 rpm. It is directly connected to a dual pinion speed increaser driving a pair of 4-stage centrifugal pumps. At left is an exterior view of this modern station showing quad radiators, air cleaners and other auxiliary equipment.

The modern installation pictured here, on a major oil company's crude line from Ventura to Los Angeles basin, is perhaps unique on the west coast. Here a Cooper-Bessemer Type JS gas engine is driving a pair of 4-stage centrifugal oil pumps through a dual pinion speed increaser. This rugged engine will give efficient, economical service for years to come and with a very minimum of down-time.

In Cooper-Bessemer Diesels and gas engines you'll find all the modern developments that contribute to long-term satisfaction in heavy-duty service. You'll also find many worthwhile advancements that are available in Cooper-Bessemer engines alone, such as tough, wear-resisting Meehanite Metal, saddle-type piston-pin-to-rod construction, efficient turbu-flow oil cooling of pistons, and many other features that mean the utmost return on your investment dollar.

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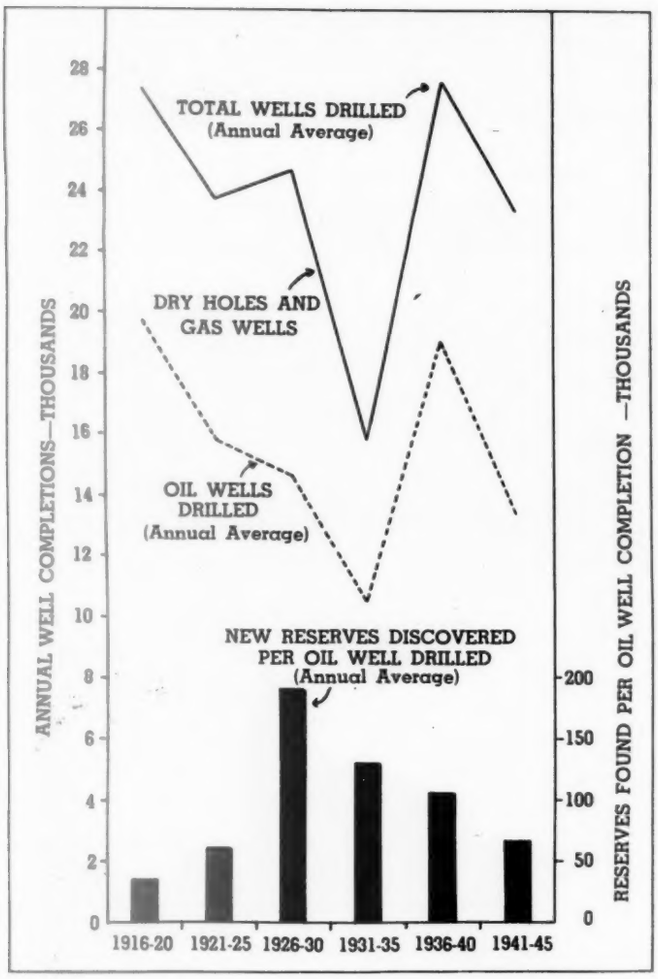


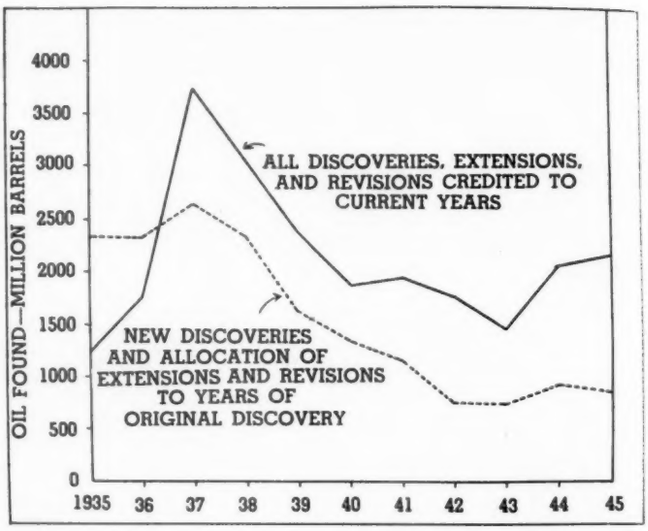


FIG. 6. (Left). HOW MANY WELLS NEEDED TO MAINTAIN RESERVES? Two billion barrels of oil must be found each year to meet future demand. At discovery rate of last 5 years it would take 50,000 wells a year to meet requirements.

FIG. 7. (Above). BULK OF DISCOVERIES ARE EXTENSIONS AND REVISIONS. Forty-seven per cent of all the petroleum found in the last 5 years was credited to previously discovered fields. The trend of such allocations has, however, been downward.

extensions and revisions of previously discovered fields. During the last 5 years, an average of 47 per cent of all the new oil discovered was credited to previously discovered fields. In 1945, the aggregate discoveries were 2,180,000,000 bbl., but 60 per cent of this oil was credited to previous years. Table 9 shows how the annual discoveries have been allocated to years of original discovery. A substantial portion of all the oil found since 1935, for example, has been credited back to the discovery of the East Texas oil field. Revisions and extensions of this field have raised ultimate recoverable reserves from 1,000,000,000 bbl. to over 5,000,000,000 bbl.

As a result of allocating extensions and revisions to years of original discovery, it is necessary constantly to revise previous estimates of proved underground reserves. Published figures place the nation's proved reserve inventory at the beginning of 1935 at a total of 12,177,000,000 bbl. However, by allocating discoveries to previous years, it is apparent that the nation's reserve inventory on January 1, 1935 was actually about 19,171,000,000 bbl. By this method of calculating reserves, it is apparent that the peak underground reserve inventory was established at the close of 1939. Since then, the industry has not actually built up its reserve inventory, but has reduced it to the extent of about 3,218,000,000 bbl. The final results, as of today, are about the same. Except for the difference in appraisal of the ultimate volume of oil discovered in 1945, the present inventory of proved reserves may be assumed to total somewhere in the neighborhood of 21,000,000,000 bbl.

If prices of crude oil are adjusted to their proper economic level, it is likely that the next few years will witness a substantial increase in extension and development drilling. An increase in the price of crude is the one incentive needed to spur the search for new sources of future oil supply. The lack of this incentive since prices were frozen has had a telling effect upon the nation's petroleum reserves situation.

★ ★ ★

TABLE 9—U. S. petroleum reserves situation.
(Revised 1945)
(All barrels are in millions)

Year	Reserve inventory January 1	New field discoveries	Revisions and extensions	Total oil found†	Production	Allocation of ext. and revisions	New field discoveries	Adjusted oil discoveries△	Adjusted reserve inventory
1935	12,177	950	270	1220	997	1375	950	2325	19,171
1936	12,400	850	913	1763	1100	1455	850	2305	20,499
1937	13,063	929	2793	3722	1278	1700	929	2629	21,704
1938	15,507	810	2244	3054	1213	1520	810	2330	23,055
1939	17,348	341	2058	2399	1264	1275	341	1616	24,172
1940	18,483	286	1607	1893	1352	1050	286	1336	24,524
1941	19,024	430	1539	1969	1404	735	430	1165	24,508
1942	19,589	260	1619	1879	1385	515	260	775	24,269
1943	20,083	282	1203	1485	1503	470	282	752	23,659
1944	20,065	511	1556	2067	1678	396	511	907	22,908
1945*	20,454	475	1705	2180	1706	400	475	875	22,137
1946*	20,928								21,306

	Method (A)	Method (B)
Reserves, January 1, 1935	12,177,000,000	19,171,000,000
Discoveries	23,631,000,000	17,015,000,000
Total	35,808,000,000	36,186,000,000
Production	14,880,000,000	14,880,000,000
Reserves, January I, 1946	20,928,000,000	21,306,000,000

†Crediting discoveries and revisions currently.
△Crediting extensions and revisions to years of original discovery.
*Preliminary.

EFFECT OF MEASUREMENT DEAD TIME IN CONTROL OF CERTAIN PROCESSES*

By **DONALD P. ECKMAN,** *Development Engineer,*
Brown Instrument Company

ONE of the most important factors in automatic control of industrial processes is the manner in which the controller mechanism responds to changes in the measured variable. This measuring lag, as it is often called, forms an extensive part of the input-output controller response relationship.

Generally, the factors of measurement dead time and dead zone are neglected in process control analysis, particularly in mathematical analysis where their inclusion results in complications of a high order. Therefore, it seems desirable to investigate the effect of these factors in automatic control in order to aid in the application of theoretical or empirical data to control problems.

Potentiometer controller mechanisms that incorporate continuous rather than periodic principles of rebalancing provide an opportunity for comparison test of these types of measuring means. Under simulated control conditions it is possible to analyze the dynamic action of the control system and the effectiveness of continuous measurement.

The measuring lag of a temperature controller is composed of two main parts: The lag of the primary element, and the lag of the controller detecting mechanism. It is this second part of the measuring lag, that due to the detecting mechanism, that we wish to study. For

*Presented before the American Society of Mechanical Engineers, November 26-29, 1945.

Automatic control tests reveal importance of mechanism response in potentiometer controllers.

purposes of discussion we may classify the many methods of operation of self-balancing potentiometer controllers under two general types: periodic action and continuous action. A periodic action potentiometer (recording type) is generally identified by a periodic mechanical system for detecting the position of a galvanometer pointer. When an unbalance of voltages is produced by a change in measured temperature, the detecting mechanism determines the amount of unbalance and drives a voltage divider or slide wire to balance against the new value of measured voltage. The periodic action potentiometer is in wide general use for both measurement and control of process variables.

The continuous action potentiometer (recording type) is generally identified[1] by the use of continuous, uninterrupted drive means, usually electronic, for obtaining the balance of measured against standard voltages. The use of continuous action in potentiometer balancing eliminates any lag due to a rebalancing mechanism, and avoids periodicity whereby a small dead time may elapse before changes in controlled temperature can be detected.

● **Tests with two-position control.** In order to determine the effect of dead time in the measuring system, it is desirable to conduct tests of two-position control. By this means, all extraneous factors may be eliminated from the tests of automatic control. Processes were selected on the process analog control board[2] by using various combinations of capacitance, resistance, and dead time.

The reaction curves for the processes to be tested are shown in Figs. 1 and 2. A reaction curve is determined by setting the valve position and allowing the measured variable to balance. A small sudden movement of the valve to a new fixed position will result in gradual increase of the measured variable to a new balanced value. The resulting time rate of change of the measured variable is the reaction curve. All processes indicate that self-regulation is present. Although the reaction curves are shown for only one direction of change, it may be assumed that the negative change produces a similar curve.

Process No. 1, shown in Fig. 1, is essentially a single capacity process with a time constant of about 6.0 min., which is the time required to achieve 63 per cent of final value. Process No. 2 is identical in characteristics except that a dead

FIG. 1.

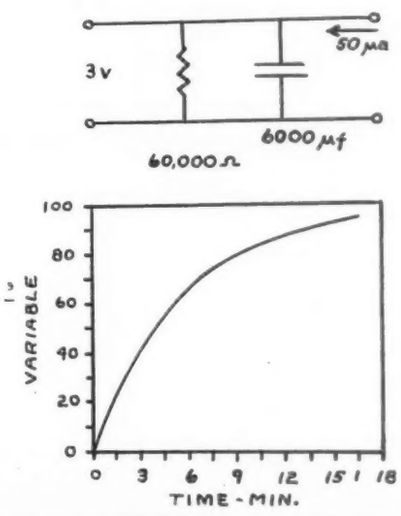
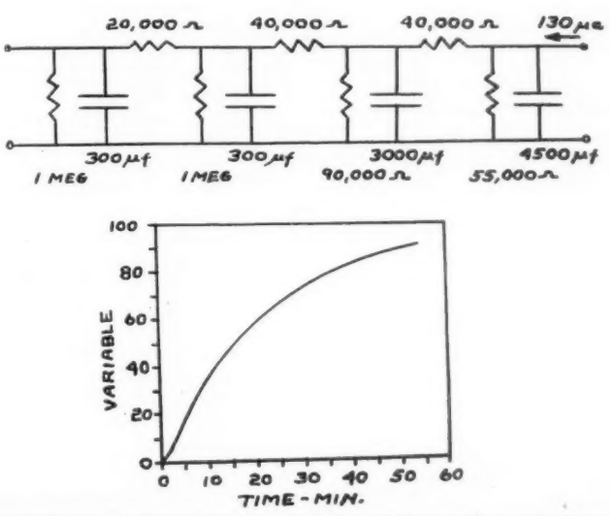


FIG. 2.



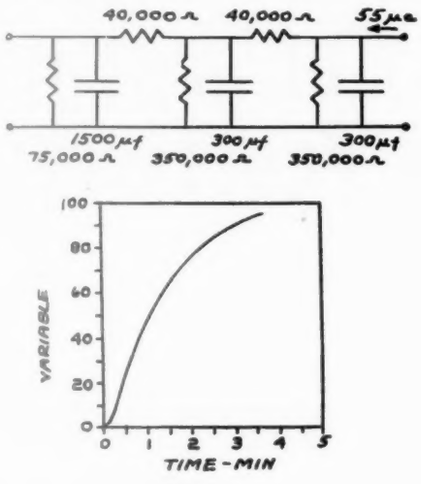


FIG. 3.

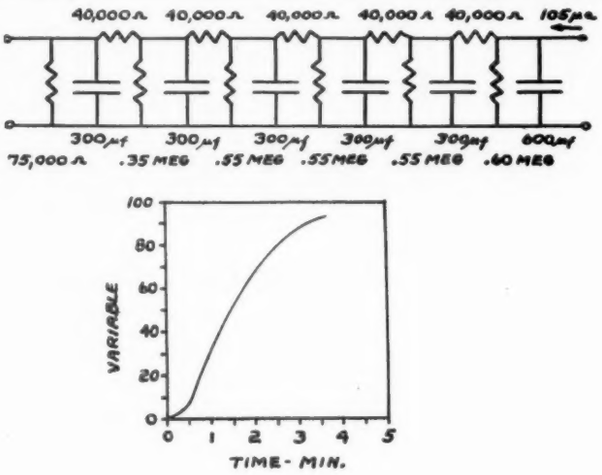


FIG. 4.

time of 0.1 min. was introduced between controller action and resultant valve movement.

Process No. 3, shown in Fig. 2, is a two-capacity process and thus involves slight transfer lag as can be noted by the slower initial rate of change on the reaction curve. Process No. 4 is identical in characteristics except that a dead time of 0.25 min. was introduced between controller action and resultant valve movement.

Each process analog was connected, in turn, to the potentiometer controller. Each potentiometer controller, a periodic action type and a continuous action type, was fitted with both pneumatic and electric two-position (on-off) control. Pneumatic control was accomplished through a pneumatic diaphragm mechanism. The proportional band (throttling range) of the pneumatic "on-off" controllers was 0.6 per cent of controller scale. The "on-off" pneumatic controller is not actually a two-position controller but is a proportional controller with a very narrow band. This controller, however, is commonly termed "on-off." Electric control was arranged so that the control contacts directly actuated the energy supply to the process. The differential gap of both electrical on-off controllers was 0.05 per cent of controller scale.

With all process and controller combinations, a cycle of controlled variable was recorded. The resulting control cycle is described in Table 1, which shows amplitude and Table 2, which shows period of cycle of the controlled variable.

The results shown in Tables 1 and 2 illustrate the improvement caused by eliminating the dead time delay in the potentiometer measuring means. This effect is particularly noticeable in processes No. 1 and No. 3 where all dead time in the controlled system is concentrated in the measuring means. In processes similar to No. 4 where considerable dead time exists in the process itself, the elimination of measurement dead time results in proportionately less improvement.

Dead time existing in any portion of the controlled system results in nearly proportional increase in amplitude. It is obvious that if automatic control is to maintain an adequate process balance then dead time in the controlled system must be reduced to a minimum.

Applying the results of these tests to applications of automatic control, it is probable that in electrically heated furnaces and baths, where the process lags are very small, the elimination of measurement dead time would result in much closer temperature control.

On the other hand, when controlling the temperature of such processes as heat exchangers where the process lags may be of minutes duration, the elimination of measurement dead time may bring no noticeable improvement.

It is interesting to note that the measuring lag may be computed from the results of controlling process No. 1 with the electrical two-position controller. Here, virtually all the lag aside from the time constant of the process is associated with the potentiometer measuring means. As in two-position control the period of cycling is about four times the total lag[3], then the measuring lag should be the period divided by four.

Thus, the measuring lag calculates to be about 0.0075 min. for the continuous action potentiometer measuring means and about 0.0645 min. for the periodic type.

● **Tests with proportional-reset control.** In order to demonstrate the effect of dead zone in the measuring means, a controller may be applied to a process and the deviation during a recovery from a load change may be expected to show differences depending upon the magnitude of dead zone.[4] The dead zone is generally defined as the greatest range of scale values within which changes in value of the controlled variable are not detected.

With self-balancing potentiometers, the width of dead zone is generally related to the construction of its detecting and balancing mechanisms. As one contributing factor, the width of dead zone is inversely proportional to the number of active convolutions of the potentiometer rebalancing slide-wire, for the controller pen and controller mechanism is

TABLE 1
Amplitude of control cycle, per cent scale.

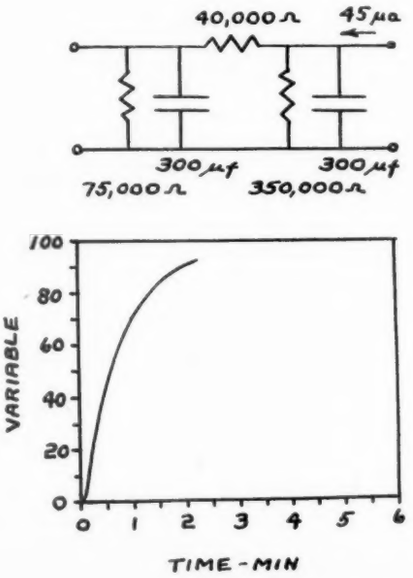
Potentiometer controller with	Type of control	Process No. 1	2	3	4
Continuous action	Pneumatic	.12	4.2	2.2	5.4
Periodic action	Pneumatic	1.80	4.6	4.2	7.1
Continuous action	Electric	.25	3.8	2.3	6.1
Periodic action	Electric	1.00	4.2	4.0	6.8

TABLE 2
Period of control cycle, min.

Potentiometer controller with	Type of control	Process No. 1	2	3	4
Continuous action	Pneumatic	0.10*	0.28*	2.4	4.5
Periodic action	Pneumatic	0.50	0.80	3.7	5.0
Continuous action	Electric	0.03	0.25	2.4	4.7
Periodic action	Electric	0.27	0.67	3.9	5.0

*Actually throttling to the extent that valve never completely opens or closes.

FIG. 5.



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generally positioned to the convolution of the slide-wire nearest the balance point.

The self-balancing, continuous-action potentiometer used in the previous tests has 1600 active convolutions on the slide-wire[1]. It was desired to test this same potentiometer with 800 and 400 convolutions on the slide-wire thus multiplying the dead zone by 2 and 4, respectively.

These arrangements were made by altering the mechanical relation between full scale pen motion and slide-wire contactor travel. An oversize drum on the slide-wire driving shaft reduced the amount of slide-wire contactor motion while maintaining the same pen motion. This change does not alter the responsiveness of the potentiometer balancing motor to a given unbalanced emf, but reduces the amount of slide-wire contactor travel for the same pen travel when a rebalancing action occurs. The electronic voltmeter on the process analog control board was then readjusted to maintain the same range of 0 to 5 volts for full scale pen travel.

The net result of these changes is to alter the number of slide-wire convolutions corresponding to a given pen travel while maintaining the same dynamic balancing action and the same scale calibration.

FIG. 6.

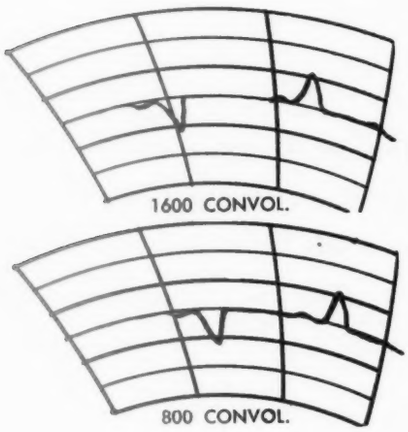
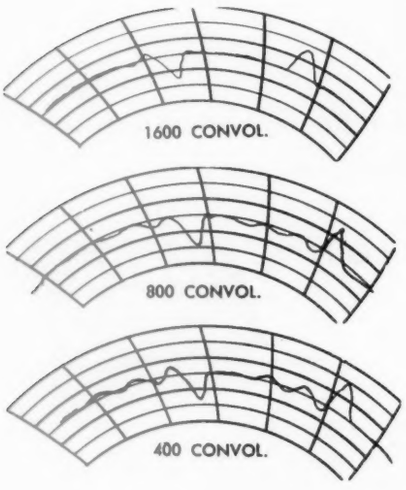


FIG. 7.



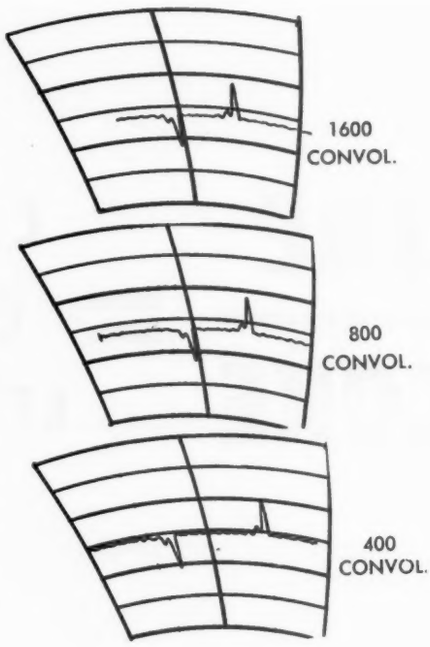


FIG. 8.

Three processes were selected and are described in Figs. 3, 4, and 5. Process No. 5, described in Fig. 3, is a relatively simple process having a moderate reaction rate and slight transfer lag. Process No. 6, described in Fig. 4, possesses a moderate reaction rate and appreciable transfer lag. Process No. 7, described in Fig. 5, has a fast reaction rate and slight transfer lag. In all tests, only the dead time inherent in the system was present and no dead time was intentionally added.

Each process analog was connected to the potentiometer controller and optimum adjustments of proportional band and reset rate selected.[5] A pneumatic proportional-reset type controller was employed for these tests. After the controlled variable had stabilized, a change in supply of energy to the process was made and the controller recovery curve obtained.

The supply change was introduced by adding a bias voltage to the existing voltage supplied to the current input unit on the process analog control board. This is, in effect, a change of flow through the control valve caused by a variation in pressure drop and requires that the controller correct for this change. The control valve has 200 effective positions.

The charts showing the recovery curves are reproduced in Figs. 6, 7, and 8. The results of these tests are shown in Table 3.

TABLE 3

Process no.	Prop. band, per cent	Reset rate per min.	Max. deviation for ± supply changes, number of effective convolutions		
			1600	800	400
5	45	0.8	11.2	11.7	....
6	60	0.4	16.7	17.7	18.1
7	25	3.0	10.0	10.4	10.6

As shown by the recovery curves of Figs. 6, 7, and 8, both an increase and a decrease in supply was made. The increase in supply results in a rise of the controlled variable before it is corrected by the controller, and a decrease in supply results in a fall of the controlled variable before it is corrected. The maximum deviation was found by adding both the positive deviation and the negative deviation. In this manner, various small non-linearities in valve characteristics, process time-constant and process lag may be averaged.

The difference between the various maximum deviations from a supply change may be attributed to the different widths of measurement dead zone in each test. With a larger dead zone, a short period must elapse between the time when an actual change in measured variable begins and the time when the controller senses the change. Thus, a measurement dead zone creates dead time. This delays the controller corrective action and allows greater deviation.

The stability of control appears to be more cyclic when the dead zone is greater. With Process No. 6 particularly, the recovery curve shows that the proportional band should be slightly increased in order to maintain the same ratio of succeeding amplitudes of cycling. There is an appreciably consistent lengthening of period when the dead zone is greater. The apparent decrease in stability of control and the lengthening of period of control points to the conclusion that an additional lag exists when the measuring means of the controller possesses a finite dead zone.

● **Conclusion.** The brief test results given here illustrate the importance of measuring lag and measurement dead zone in automatic control. It is desirable to maintain measurement dead time as small as possible, for it increases the quality of control, especially on those processes where all other lags are small. It is desirable to maintain measurement dead zone as small as possible for it increases the quality of control by accomplishing a reduction of dead time.

It is evident that more investigation is required to establish further the relationship between each component part of measuring lag and the measurement dead zone. In most control problems the effect of these factors cannot be ignored because of their influence on the quality of automatic control.

The author gratefully acknowledges the suggestions of T. R. Harrison in the investigation.

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LAYING DOWN DRILL PIPE

By **WILLIAM J. DAVIS**
Assistant Field Editor

EXCLUSIVE *Petroleum* **Engineer Picture** *Story*

DRILLING contractors are constantly searching for methods of lowering drilling costs. They know that the man who can make hole to the satisfaction of the oil company that patronizes him and at the same time keep costs down is the man who is showing a profit for his company's equipment. Various methods are tried to cut rigging-up and tearing-down time, the time-consuming periods of a drilling contract in which all moneys involved are on the debit side of the ledger with no off-setting figure in the credit column. One phase of the tearing-down period is the time spent in laying down drill pipe. Pictured on these pages is how one drilling contractor in West Texas has attacked the problem.

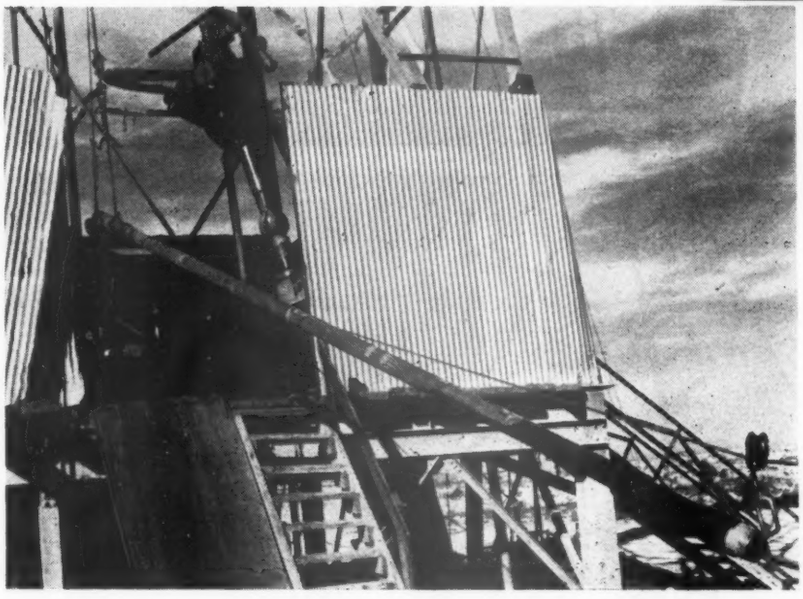

FIG. 1. Use is made of a "mouse" hole that is within a few feet of the perimeter of the rotary table and on the open "V" side of the derrick. This hole is used to break out joints with the regular tongs and spinning rope. A light line is made fast with the use of wire-line clamps to the first girt of the derrick on the opposite side of the "V" and the far end is fastened to the end of the walk in the same manner.

FIG. 2. Left—The tailing-out man has nothing to do but return the trolley to the derrick floor by starting it vigorously on its way up the incline. Each joint of pipe unhooks itself automatically when the trolley hits the bumper at end of walkway.

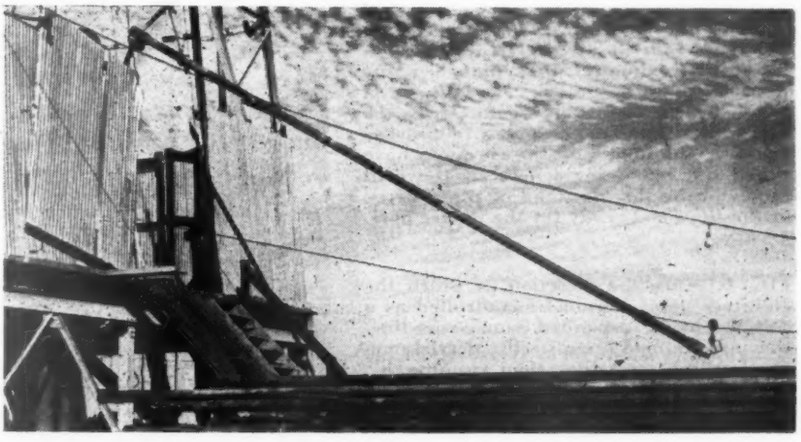

FIG. 3. Right—A 55-gal. drum is placed under the line at the end of the walk in such a manner that the line is raised approximately 3 ft. A 4-in. snatch-block with a hook attached to the eye is used as a "trolley" on the wire line for tailing out each joint as it is laid down. A bumper of soft line wrapped around the trolley line just ahead of the 55-gal. drum prevents the pulley from over-running. Any possible damage to tool joints is avoided by breaking the fall of the drill pipe with a 4-by-6 timber used as a runner to the pipe rack. Opposite end of drill pipe is under control at all times as the cat line is attached, until released by a floorman, on the first and second joint of each threble and the light elevators on the last joint.

FIG. 4. An unusual use has been made of the 8-line traveling block and hook to produce a rapid return of the elevators to the monkey board and derrickman. A snatch-block was secured to the hook by means of several turns of wire line and wire-line clamps. A ¾-in. sand line was passed through the pulley and back to the derrick floor where a double sling was made in one end and the elevators rigged thereto. The opposite end of the sand line was fouled under four turns of the drilling line on the main drum and a wire-line clamp put on the extreme end to prevent slipping through the turns of heavy drilling line.

FIG. 5. Final adjustment of sand line length was made with two turns of sand line on the drilling drum, elevators just touching the floor, and snatch-block at eye level of the derrickman. In operation the hook with its 16 to 1 travel ratio is raised approximately 5 ft. higher in the derrick to cause the elevators to travel from the floor to derrickman. Once the derrickman has latched on, a few inches travel of the hook and the elevators have raised the remaining length of the drill pipe and the threble stand of pipe is free of the floor and ready for the mouse hole.

FIG. 6. Since the direction in which the elevators point cannot be controlled as a result of being suspended from a wire line, they are stopped opposite the derrickman for latching on rather than running by.

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MOTOR VOLTAGE SELECTION IN OIL REFINERIES

By **E. KUN,** The Lummus Company

The selection of voltages for motors in oil refineries and similar industrial plants is commonly determined in accordance with rules and practices established for a number of years, and not on the basis of economy as affected by the latest developments in the arts and with consideration to supply system requirements.

Three-phase motors for 440-volt and 2200-volt service are the types most frequently used, with a dividing line varying between 50 and 100 hp. with the different industrial plants. The reason for going to 2200 volts for 100, 75, 60, and even 50-hp. motors is said to be a saving in cables and conduit for the motor circuit, and a saving of transformer capacity when the usual 2300-volt distribution system is available. Formerly when 2200-volt motor control equipment of standard type (NEMA—1 enclosures), and low interrupting capacity could be used, a saving could be obtained by applying the higher voltage to motors of sizes under consideration. Today, however, due to the more or less universal requirements of the so-called "explosionproof" (Underwriters' Class 1, Group D type) control equipment, and the higher interrupting capacities demanded by the electrical system, the use of the higher voltage, for sizes of motors up to and somewhat above 100 hp., usually results in a waste of money and space for control equipment.

The purpose of this article is to determine the practical limitation of motor sizes for the economical application of voltages. The accompanying tables contain approximate costs of material that are representative figures for motors, control equipment, and wiring in oil refineries, where Class 1, Group D type equipment must be used. These figures should suffice for comparison, as labor costs are about proportional to costs of material.

Comparison of Tables 1 and 2 indicates that motors of sizes up to and including 125 hp. should definitely be for 440-volt service. In case of 150-hp. motors the figures indicate a slight saving in favor of the 2200-volt motor. It must be remembered, however, that the cost of motor feeders, incoming line equipment, etc., varies with local conditions, and the figures may vary slightly in favor of either voltage. The deciding factor should be, in this case, the higher maintenance of the high voltage control equipment, for which reason 440-volt equipment will prove more economical in the end for 150-hp. motors. For 200-hp. motors and above 2200 volts should be selected, with equipment such as included in the tables.

There are two other types of 2200-volt control equipment very often used in oil refineries. One is of switchboard panel construction, employing a low interrupting type oil-immersed contactor with a set of high interrupting capacity type, current limiting fuses in disconnecting mounts. The cost of such equipment for semi-hazardous locations is approximately $1650 list (including controller, disconnecting device, bus and interconnections) and, therefore, the above conclusions should also apply when such equipment is considered.

Another 2200-volt control equipment is the so-called "metal clad" switchboard panel type, employing oil circuit breakers of 50,000-kva. interrupting capacity, disconnectable by means of a lowering device. The cost of such a panel is approximately $2500 net (including controller, disconnecting device, bus and interconnections) indicating that even 200-hp. motors should be for 440-volt service for economy, where such 2200-volt equipment must be used.

An analysis, similar to the above, but based on standard industrial equipment, was presented in a recent issue of the *General Electric Review*, by D. L. Beeman of the Industrial Engineering Division, General Electric Company. Beeman's conclusions are that "For motors less than about 200-hp. rating, reference to curves . . . will show that 440-volt motors make possible the least investment in the electric equipment, regardless of primary voltage. Thus, all motors rated about 200 hp. or less should be operated on systems rated 600 volts or less, regardless of the primary voltage selected." He also states that "the effect of explosionproof requirements will have little bearing on the basic factors . . . ," which statement coincides with analysis presented here.

Beeman further states that "Where a choice of primary voltage can be made, it is usually more economical to select 4160 volts than 2400 volts—even where the percentage of motors above 200 hp. is as high as 50 to 60 per cent of the total plant load."

As a rule, oil refineries use 2300 or 2400-volt systems with 2200 or 2300-volt motors for the larger sizes. Motors for 4160 volts are somewhat more expensive than for 2200 volts. The present approximate costs of 4160-volt, 3-phase, 60-cycle, 1800-r.p.m., squirrel-cage, explosionproof motors are:

75 hp.	$1550
100 hp.	1950
125 hp.	2360
150 hp.	2560
200 hp.	2960

The cost of control equipment and other items, for 4160-volt service, is about the same as given in Table 2. Therefore, in a new development where the choice between 2300-volt and 4160-volt distribution is not impeded by consideration for existing installation, the choice can be based on the saving in the distribution system effected by the use of the higher voltage, as against the higher cost of the 4160-volt motors.

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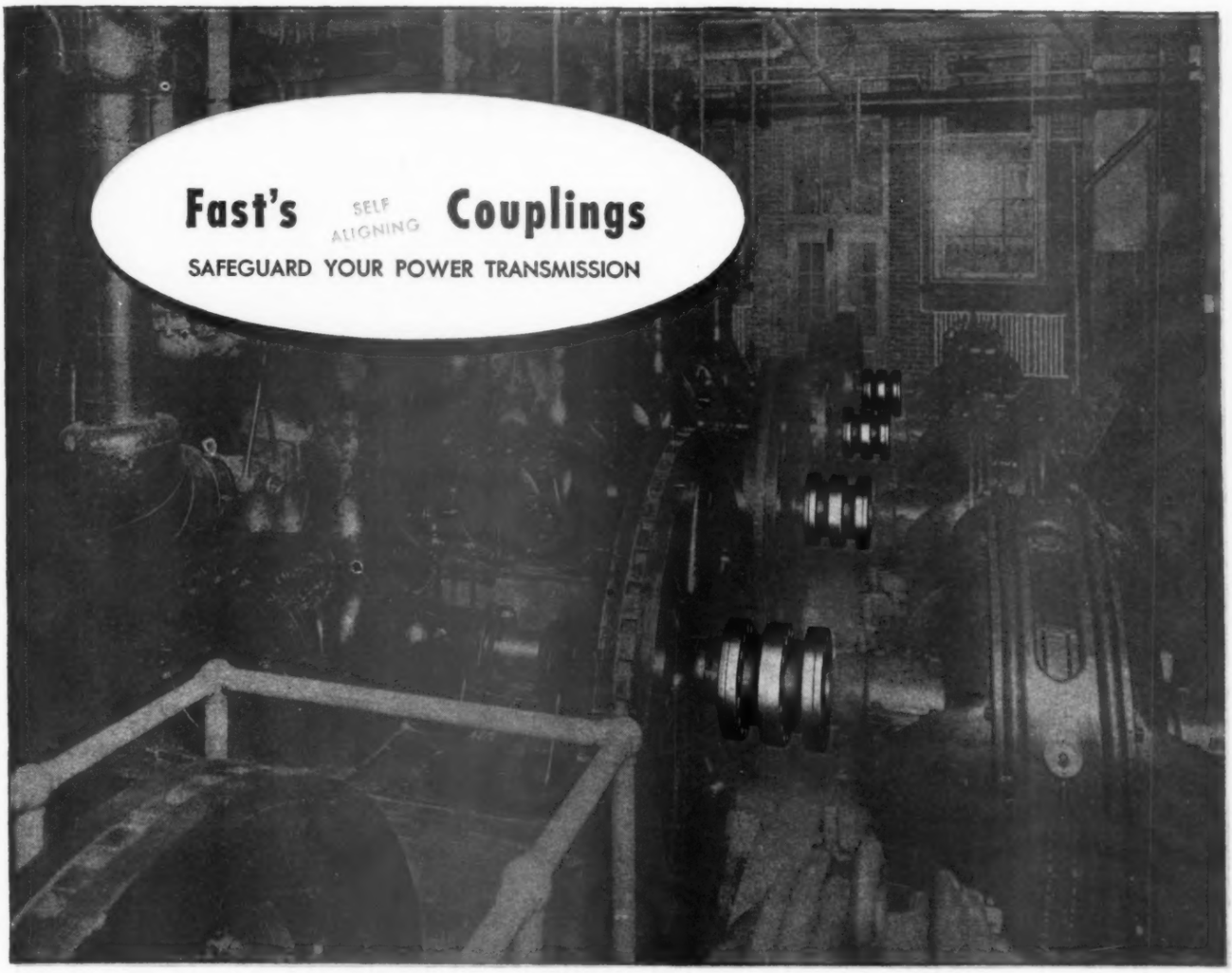
TABLE 1—440-volt equipment.

Horsepower	60	75	100	125	150	200
Motor, 440-volt, 3-phase, 60-cycle, 1800-r.p.m., squirrel-cage, explosionproof	$ 851	986	1294	1660	1923	2456
Controller, 440-volt, combination type, oil-immersed magnetic, across-line, with circuit breaker, Class I, Group D, construction, including explosionproof push button station mounted at motor	410	410	410	850	850	850
440-volt enclosed bus and inter-connections at controller assembly	53	57	64	108	112	135
Motor feeder (varnished cambric insulated, lead covered cables) also push button pilot cable, including conduits and fittings for both, based on 100 ft. length	184	225	273	387	438	550
Estimated share of main 440-volt circuit breaker, and incoming service feeder	150	190	250	315	375	500
Estimated share of 2400/480-volt transformer station	240	300	400	500	600	800
Total of all items	$1888	2168	2691	3820	4298	5291

TABLE 2—2200-volt equipment.

Horsepower	60	75	100	125	150	200
Motor, 2200-volt, 3-phase, 60-cycle, 1800-r.p.m., squirrel-cage, explosionproof	$ 972	1107	1385	1746	2005	2514
Controller, 2200-volt, oil-immersed, magnetic, across-line, with 50,000 kva. interrupting rating Class I, Group D construction, including explosionproof push button station mounted at motor	1340	1340	1340	1340	1340	1340
Disconnecting switch, 3-pole, oil-immersed, 5-kv. or 7.5-kv. rated	205	205	205	205	205	205
2200-volt bus and interconnections at controller assembly	160	160	160	160	160	165
Motor feeder, (varnished cambric insulated, lead covered cables) also push button pilot cable, including conduits and fittings for both, based on 100 ft. length	195	195	195	195	195	235
Estimated share of main 2200-volt incoming line panel and incoming service feeder	250	250	300	300	300	350
Total of all items	$3122	3257	3585	3946	4205	4809



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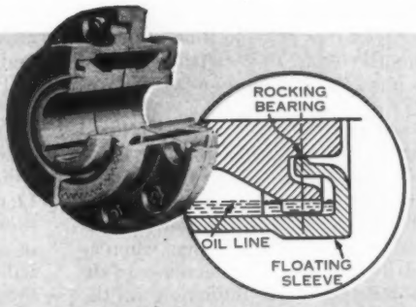

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TIME BUDGET FOR DRILLING OPERATIONS

By **W. K. POWELL,** *Assistant General Manager,*
Two States Drilling Company

TIME is the essence of much gain. It is strange how this maxim has been discovered so often in the past by men such as Alexander, the de Medeci, Napoleon, Franklin, Forrest; it has been forgotten and rediscovered intermittently by men such as Ford, Kaiser, and Eisenhower to make them famous and rich.

EXCLUSIVE

From its infancy the oil industry has been goaded by the tremendous lure of additional riches into the conquest of time. Under the old rule of capture, the first wells completed were usually the biggest wells and produced rapidly most of the oil from the discovery sands, and the wells completed later produced as much oil as possible from what was left. The economic consequences of oil "floods" sobered this practice, but still the race against time roared through the mud and dust and sweat, and the industry turned to attack lost time in all its other phases.

Thousands of charts, records, and graphs have been constructed for use in the determined effort to reduce the time of oil discovery operations, of drilling and production operations, of transportation methods, of refinery practices, of distribution and marketing operations. The approach in each case was different. Simultaneously with new interpretations of the ancient rule of capture, changes occurred in production practices that placed emphasis on reducing the cost of drilling and completing wells for production. Present production practice recognizes as an axiom the direct relation between cost and the time of operation, and the tempo of the drilling operation is being constantly increased to reduce the cost of drilling.

● **70 per cent of drilling costs related to time.** Some of the costs of drilling are very difficult to lower, being nonrecurrent, fixed charges for each well drilled, but these constitute only about 8 per cent of the total costs, whereas those drilling costs that decrease in direct proportion to a reduction in the elapsed time of activity amount approximately to 70 per cent of all costs. Of the seven major factors of drilling expense discussed in the Manual of Uniform Accounting Practices published by the American Association of Oilwell Drilling Contractors, four accounts may be classified as direct-ratio expenses for all practical purposes. Quoting from the Manual, these items and their partial extensions are:

Labor and supervision: Labor, supervision, workmen's compensation and public liability insurance, crew transportation, social security taxes, auto expense, and supervision.

Supplies: Rig supplies, hand tools, valves, fittings and line pipe, oils and greases, fire and other insurance.

Maintenance and repairs: Drawworks (repairs and parts), pumps (repairs and parts), power and transmission (repairs and parts), overhead string (repairs and parts), other equipment (repairs and parts), general maintenance expense, fishing (repairs, parts and rentals), drilling string (repairs and parts).

Depreciation: Rig depreciation, drill pipe depreciation.

All these expenses can be reduced to a per day unit of cost, so it is not difficult to determine in dollars the advantages to be gained from any savings that can be made in drilling time. Assuming, for instance, that the direct-ratio costs in a given area total $500 per day, a reduction of 5 days in the average drilling time would result in a saving of $2500 per well, a reduction of ten days would save $5000, and so on.

None of the seven major cost factors referred to above is composed entirely of fixed charges. Such charges occur as components of the two major groups referred to in the Manual as "Ordinary Operating Expense" and "Other Operating Charges." Typical examples of the expenses that are not affected appreciably by the drilling time are: Transportation of drilling equipment to and from location, excavation of pits and cellar, erection and tearing down of derrick, mat lumber, rig timbers, roads, bridges, clearing location, and purchase of water and fuel on a flat fee basis.

The remaining 22 per cent of the drilling expenses do not vary in direct proportion to time. These are such items as bits, fuel and water purchased on a volume basis, mud, chemicals, and major factor Number 7, "Overhead." All of these items may be reduced in amount in some cases, but the reduction ratios will vary erratically with time. Even though a few of the expenses selected previously as direct-ratio (time to expense) items may be slightly debatable, there are probably enough savings in the expenses of erratic-ratio relationships to give a good margin of safety to the statements made herein with regard to the value of obtaining the maximum efficient performance in drilling.

Considering only the direct-ratio expenses, which equal 70 per cent of the total drilling costs, it is interesting to note the effect (in percentage) on the entire expense of drilling from various degrees of change in the drilling time. The direct relationship between time and expense is as follows:

1 per cent variation in drilling time changes the drilling cost 0.7 per cent.
2 per cent variation in drilling time changes the drilling cost 1.4 per cent.
3 per cent variation in drilling time changes the drilling cost 2.1 per cent.
5 per cent variation in drilling time changes the drilling cost 3.5 per cent.
10 per cent variation in drilling time changes the drilling cost 7.0 per cent.
15 per cent variation in drilling time changes the drilling cost 10.5 per cent.
20 per cent variation in drilling time changes the drilling cost 14.0 per cent.
25 per cent variation in drilling time changes the drilling cost 17.5 per cent.
50 per cent variation in drilling time changes the drilling cost 35.0 per cent.

Recognition of the possibilities of making appreciable savings by reducing drilling time has given rise to numerous methods of time accounting and analysis necessary for proper management of the drilling operation, but one of the most promising time controls in use is the budgeting of time. Estimates of time have always been made, but these estimates were ordinarily made chiefly for the purpose of ascertaining a fair price or cost and were usually regarded in total. By extending these estimates and formalizing them as budgets of time, the managements of drilling operations are being remarkably successful in correcting conditions that tend to slow the work.

● **Division of time elements.** Making use of the natural functional time segments of the total drilling operation, the budgeteers, prior to beginning operations and usually as an activity connected with bidding or estimating, allot an estimated normal period of time to each of the following time groups:

Rig up
Surface casing through drilling plug
Intermediate string (if any) through drilling plug
Oil string through drilling plug
Drilling in
Day work
Tear down

All or any part of these divisions may be further separated as the need exists. For example, it is common to find assignments in the schedule of the time expected to be consumed in drilling to various budget points in depth. The time allotted to each function will be obtained from the experience of the operator in the given area or in similar areas or

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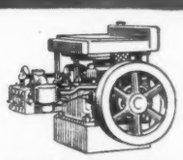

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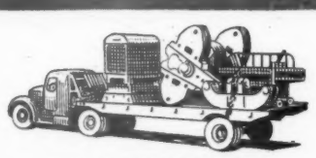

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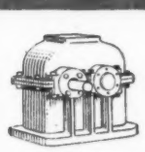

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DIVISION LUFKIN FOUNDRY & MACHINE COMPANY INDUSTRIAL, MILL AND AUTOMOTIVE SUPPLIES •

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from the records and experience of others.

In whatever manner the estimate is made the greatest value can be obtained from it only, if there is complete agreement between the supervisory and management personnel as to the allocation of time to each function. The budget must be practical and obtainable. The time agreed upon must be that which can be expected under normal conditions and with the available equipment. Underestimates of time requirements will result only in discouragement of the supervisory personnel, misunderstandings, and a final abandonment of the method. The whole thing is designed to reflect the normal operation to the extent that bad practices will be immediately spotted and good practices may obtain immediate recognition. The budget, being divided into familiar sections, permits a higher concentration of effort in making more effective use of time because smaller, more digestible spans of time are under observation.

After the budget is cast, it should be made available to all affected parties in some visible and quickly assimilable form from which instant comparisons

EXAMPLE OF A TIME BUDGET DRILLING RECORD

Location: _____

Field: Fullerton

County-State: Andrews, Texas

Well No. 86

Rig No. 3

Fullerton-Typical No. 1

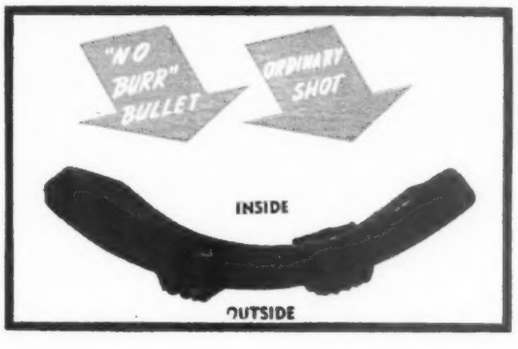
LEGEND

Rig Up and Tear Down	R
Surface Hole	S
Salt String	X
Oil String	O
Drilling In	C
Day Work	D

1	2	3	4	5	6	7	8	9	10	11	12	13			
Budget		Active time			Elapsed time		Depth reached, ft.	Troubles time, hr.	Day work, hr.	Explanation	Trips, hr.	Bits			
Depth points, ft.	Days	Actual days		Depth points, ft.	Date	Time						No.	Size, in.	Type	Depth
	R	1	R		6-27	R				3 tours: rigging up					
	R	2	R		6-28	R				3 tours: rigging up					
	R	3	R		6-29	R				3 tours: rigging up					
	R	4	R		6-30	R				3 tours: rigging up					
	S	5	R		7- 1	R				3 tours: rigging up					
	S	6	R		7- 2	R	46			3 tours: rigging up		1	17¾	drag	0
	X	7	S		7- 3	S	75			ran surface casing; 18 hr. W.O.C.	¾				
	X	8	X		7- 4	X	630			8 hr. W.O.C.	½	1	11	rock	75
	X	9	X		7- 5	X	1120								
	X	10	X		7- 6	X	1319				1				
	X	11	X		7- 7	X	1690				1	2	11	rock	1319
	X	12	X		7- 8	X	1770	2		Pump and mud connection	2	3	11	rock	1723
	X	13	X		7- 9	X	2030								
	X	14	X		7-10	X	2368	4		Repaired pump	2	4	11	rock	2094
	X	15	X		7-11	X	2845								
	X	16	X		7-12	X	2962	6		Repairing mud lines and pumps	2	5	11	rock	2875
	X	17	X		7-13	X	3069	1½		Broke tool joints	3	6	11	rock	3032
	X	18	X		7-14	X	3242				1½				
	X	19	X		7-15	X	3376				1½	7	11	rock	3242
	X	20	X		7-16	X	3496	1½		Working on engines	3	8	11	rock	3457
	X	21	X		7-17	X	3640								
	X	22	X		7-18	X	3748	4		Repaired engine chain	3	9	11	rock	3640
	X	23	X		7-19	X	3810	1½		Working on swivel	3	10	11	rock	3768
	X	24	X		7-20	X	3889	1½		Worked on chain and mud line	3	11	11	rock	3824
4000	X	25	X		7-21	X	3960				3	12	11	rock	3904
	X	26	X	4000	7-22	X	4035	1½		Engine chain	3	13	11	rock	3992
	X	27	X		7-23	X	4065			Ran 7¾-in. casing; 3½ hr. W.O.C.	3				
	X	28	X		7-24	X				24 hr. W.O.C.					
	O	29	X		7-25	X				24 hr. W.O.C.	3	1	6¾	rock	4065
	O	30	O		7-26	O	4209			2½ hr. W.O.C.					
	O	31	O		7-27	O	4359				3	2	6¾	rock	4242
	O	32	O		7-28	O	4460	8½		Out of water	1½				
	O	33	O		7-29	O	4597	7½		Out of water	1½	3	6¾	rock	4460
	O	34	O		7-30	O	4698	11		Fishing	1½	4	6¾	rock	4597
5000	O	35	O		7-31	O	4795	5		Out of water	3½	5	6¾	rock	4698
	O	36	O		8- 1	O	4985	1		Out of water	3	6	6¾	rock	4881
	O	37	O	5000	8- 2	O	5184				3	7	6¾	rock	5045
	O	38	O		8- 3	O	5431				3½	8	6¾	rock	5244
	O	39	O		8- 4	O	5597	1		Working on chain	5	9	6¾	rock	5430
	O	40	O		8- 5	O	5680	3½ 8½		Working on chain and clutch; Fishing	2	10 11	6¾ 6¾	rock rock	5597 5680
6000	O	41	O		8- 6	O	5901	1½		Working on clutch	4	12	6¾	rock	5853
	O	42	O	6000	8- 7	O	6066				4	13	6¾	rock	6030
	O	43	O		8- 8	O	6211				4	14	6¾	rock	6105
	O	44	O		8 -9	O	6312				6	15	6¾	rock	6238
	O	45	O		8-10	O	6406	3		Worked on drawworks	4	16	6¾	rock	6312
	O	46	O		8-11	O	6490				6	17 18	6¾ 6¾	rock rock	6406 6467
	O	47	O		8-12	O	6514	14		New block and crown	2	19	6¾	rock	6514
	O	48	O		8-13	O	6538	6		New block and crown	6	20	6¾	rock	6527
	O	49	O		8-14	O	6630				4	21	6¾	rock	6594
6750	O	50	O		8-15	O	6705	1		Worked on drawworks	4	22	6¾	rock	6628
	C	51	O		8-16	O	6740			Running casing	2				
	C	52	O		8-17	O	6740			Ran 5½-in. casing: W.O.C.; washed boilers and pits; put on blowout preventer					
	C	53	O		8-18	O	6742			Running and picking up tubing					
	C	54	C	6750	8-19	C	6775			Drilled plug; changed flow line; tested blowout preventer; added mud	2	1	4¾	rock	6742
	C	55	C		8-20	C	6811				4	2	4¾	rock	6781
	C	56	C		8-21	C	6886			Repaired rotary chain	4	3	4¾	rock	6862
	C	57	C		8-22	C	6966				2				
	R	58	C		8-23	C	7035					4	4¾	rock	6966
	D	59	C		8-24	C	7084				4	5	4¾	rock	7056
	D	60	C		8-25	C	7127				4	6	4¾	rock	7115
		61	C		8-26	C	7173				5	7	4¾	rock	7138
		62	D		8-27	D	7180		24	Compounded pumps: acidized with 500 gal.: swabbed well; killed going in hole with packer					
		63	D		8-28	D	7180		24	Ran packer: acidized with 400 gal.: swabbed and tested					
		64	D		8-29	D	7180		24	Changed chokes: acidized with 8000 gal.: swabbed: testing; killed; loose working packer					
		65	D		8-30	D	7180		24	Set packer: acidized with 4000 gal.					
		66	D		8-31	D	7180		24	Swabbed well; jetted pits; killed; pulled packer					
		67	R		9- 1	R	7180			Swabbed in well; tearing down					

Small Item With a Big Future

Out of the Schlumberger research laboratory has come this improved bullet to solve, at long last, the problem of steel burrs turned up on the inner wall of the oil string when it is gun perforated. We call it the "No-Burr" bullet. It consists of a standard Schlumberger bullet, over the nose of which is attached a soft metal cap. When the bullet is fired the cap travels with it and contacts the casing with sufficient impact to prevent the forming of a burr. Consequently, casing perforated with Schlumberger "No-Burr" bullets offers no obstructions to close-fitting packers or other bottom hole completion equipment. A glance below at the un-retouched photograph of a section of perforated casing tells the story. Henceforth, "No-Burr" bullets will be used exclusively on Schlumberger gun perforating operations . . . another *first* for Precision Gun Perforating. *Schlumberger Well Surveying Corporation, Houston, Texas.*



SCHLUMBERGER "NO-BURR" BULLETS

may be made with current progress. The budget may be combined effectively with the current operations reporting sheet, which completed becomes a permanent record of progress for comparison and analysis. The accompanying chart is an example of this method of employing the budget and is an actual chart, after completion, of a typical well in the Fullerton field of Andrews County, Texas.

In this chart an equal space is allotted to each day, and the day is broken into three equal tours, although finer divisions may be employed if desired. Column 3 of the illustration is used to designate the numerical sequence of days and as a separator for Columns 2 and 4. Column 2 is completed before the well is started by laying out the budget time in its natural functional sequence (except daywork, which will be explained later) and indicating the transition from one occupation to another with lettering and heavy division lines as in the example, or with color, as in the original. Column 1 is used to indicate various actual points described in depth or geological structure to be reached by the indicated time. Also the sheet is previously prepared with the proper identifying data at its head.

● **Chart kept daily.** After the layout of the budget is made, the chart is posted daily with pertinent information of daily progress. The actual date is inserted in Column 6 and the maximum depth attained during the day is placed in Column 8. Into Column 7 goes the graphic key employing the same legend of symbols used in Column 2 and to be used in Column 4, to indicate the nature of the work done each day. More complete information about the use of time is given in the columns that follow to the right. The hours of shutdown time for machinery failure, fishing, and other causes are noted in Column 9, while Column 10 is used to indicate the time used on daywork. Column 12 is likewise an "hour" column, as it is used to record trip time. Bits are recorded in Column 13 with depths at which they were run. Details necessary to explain the events of each day are posted in Column 11.

As Column 7 grows daily with the progress of the well, it indicates the total elapsed time to date and finally to completion. At any time there is no activity at all the necessary time spaces of this column are left blank to indicate such inactivity. Eliminating any such idle sections, the time functions of Column 7 are transferred to Column 4 in compressed form to become comparable with the budget column No. 2. Day work, which may appear at any point within Column 7 for chronological time, is extracted when transferring to Column 4 and placed at the very base of the column, which position daywork also occupies in the budget shaft.

In usage, Column 4, indicating active time, is compared daily with the budget column and all variations are noted and investigated. For example, in the illustration, when the well was spudded, the chart showed that rigging up had consumed two more days than planned in the budget. This information was impressed on all concerned at the time of happening and not by analysis after completion of the well when memories had become dull. Prompt investigation in this case resulted in corrections that permitted attainment of the budget goal for rigging up on subsequent wells. Knowledge of the time lost may have been instrumental in picking up two-thirds of a day in the next operation of drilling surface hole and setting pipe as there was no other reason found to account for the gain in time. The intermediate or salt string was set after a lapse of time almost identical with the budget but a loss of two days was sustained in achieving the bottom of the hole. Reference to the trouble column (No. 9) and to its explanation in Column 11 reveal why more time was consumed than planned; for instance, 20 hr. were used in the installation of new crown and traveling blocks. These explanations naturally bring up discussions as to the reasons for the specific work stoppages and may well lead to the establishment of new, clearly defined company policies that will obviate similar circumstances in the future.

● **Budget measures achievement.** The budget as a tool has a place both in the field and in the office. In the field, it is an attainable target for each phase of the drilling operation, telling in clear and unmistakable terms the success of the operations. It is a spur to greater achievement. It is a measuring device for experiments with material, men, and procedures. For the office the budget likewise performs many functions, chief among which are planning, estimating, and policy making. It is the right hand of drilling management.

With all of its advantages it seems likely that the time budget may help fill the very great need to reduce drilling costs for greater depths. In general, competitive conditions have forced reasonable costs at lesser depths without anyone knowing particularly how it was done, but in order to reach 15,000 ft. and below economically at this time it is going to be necessary to do some real scientific planning and research. The results obtainable from an intelligent use of time budgeting and analysis should dictate improvements that will make possible the greater depths. The equipment manufacturer is alert and able to meet requirements admirably as soon as they are recognized.

It would seem that proper study of the time element would develop the necessary data to indicate the kind of improvements in materials and procedures needed to best accomplish this result. It is much easier to obtain a specific necessity than it is to wish for improved machinery for deeper drilling. What are the slow points? All actions using considerable time should be investigated thoroughly from every angle, with the idea of eliminating or reducing the time use. For again, time is the essence of much gain, and to the conqueror of time may go those riches resting at costly depths.

★ ★ ★

P 644.1

METHOD FOR MOVING STEEL TANK TO ANOTHER SITE

SINCLAIR-PRAIRIE Oil Company had occasion recently to dismantle, move, and erect on a new site the bottom and lower two rings of a 35,000-bbl. steel tank of riveted construction. Faced with a shortage of skilled tank moving personnel and equipment, the company used a method of dismantling and assembling in which no rivets were sheared or replaced.

The entire job was done by carefully marking, cutting, and rewelding the entire structure.

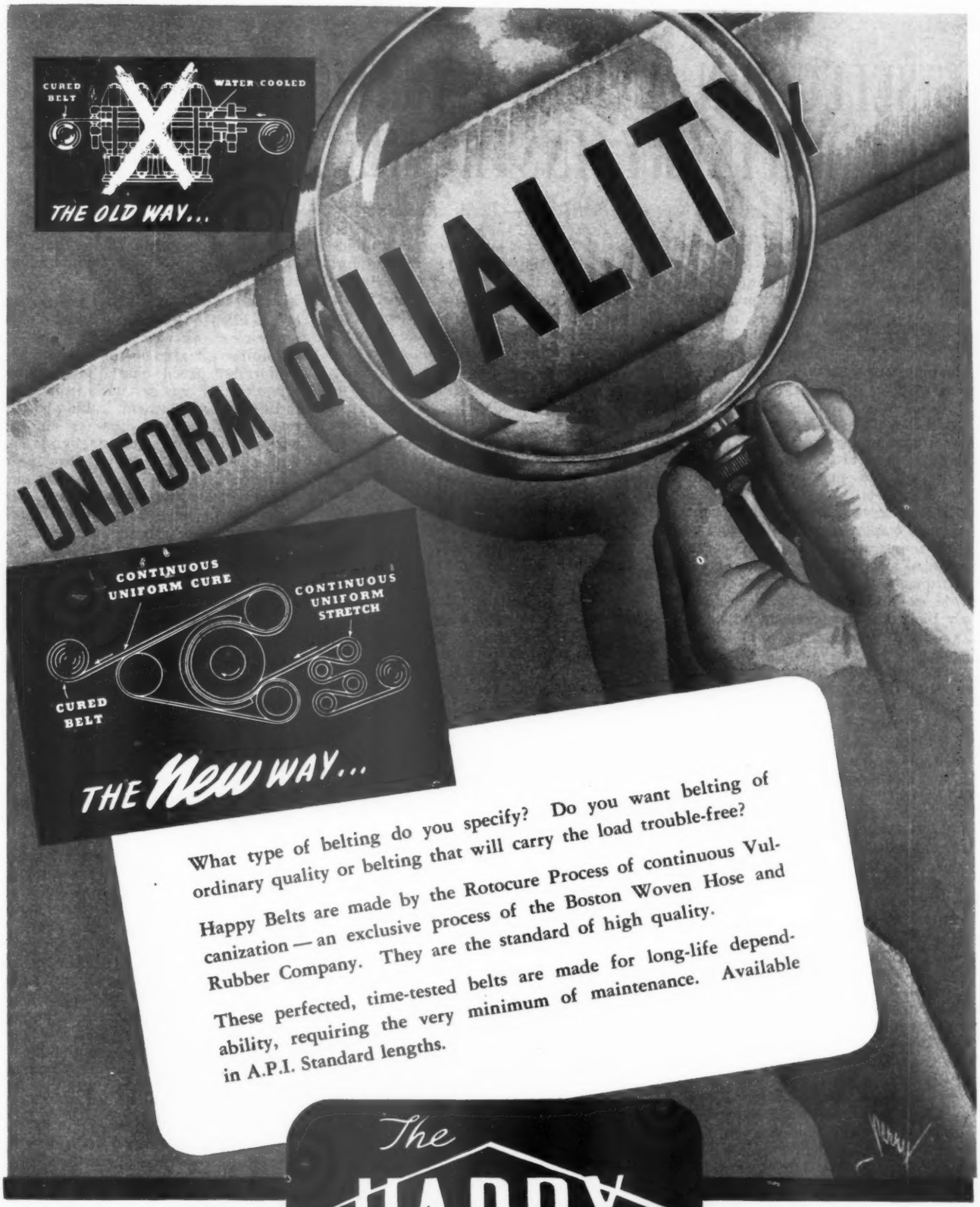
The first step was to cut the bottom loose from the shell 18 in. inside and parallel to the shell. The circular shell was then marked off into 21 equal segments and cut up accordingly. This gave trailer loads 9 ft. 6 in. wide, which was the height of the 2-ring shell, and approximately 14 ft. long with the 18-in. section still attached at right angles.

The bottom of the tank, which was now reduced to 92-ft. diameter, was cut into 8 ft. widths and trailer lengths and moved to the new site.

Each piece of the bottom was reassembled in its proper order on the new foundation and butt-welded together. The shell was then erected about the tank bottom and butt-welded in place. Two angle iron girts were welded around the outside of the shell, one midway between top and bottom to strengthen the structur, and the second at the top to reinforce the edge and finish the job.

When filled and tested with water, only a few rivets needed welding over to stop leaks.

★ ★ ★



What type of belting do you specify? Do you want belting of ordinary quality or belting that will carry the load trouble-free?

Happy Belts are made by the Rotocure Process of continuous Vulcanization — an exclusive process of the Boston Woven Hose and Rubber Company. They are the standard of high quality.

These perfected, time-tested belts are made for long-life dependability, requiring the very minimum of maintenance. Available in A.P.I. Standard lengths.

Happy Coolers
Rubber Belting
Leather Belting
V Belts
V Belt Sheaves
Happy Pumping Units
Power Transmission Equipment

The HAPPY COMPANY
Formerly HAPPY BELTING COMPANY
TULSA, OKLAHOMA

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Odessa	Texas
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SELECTION AND APPLICATION OF REFINERY INSTRUMENTS

By **ALFRED KRIEG***
Socony-Vacuum
Oil Company, Inc.

PART 2 — TEMPERATURE

● **Preface.** There has been rapid advancement in the design of refinery units during the last 10 years. Units in general are now "streamlined" in design to a point where a minimum of equipment is required to obtain a maximum throughput. By stepping up fluid velocities, improving heat transfer rates, and decreasing stored liquid capacities, the process units of today are seemingly no larger in physical size than those of 10 years ago, although their capacities may be double that of the older units.

EXCLUSIVE

This naturally has its effect on the methods employed to measure and control. Temperature control is generally accepted to be of major importance for instrumentation in petroleum refining processes and in order to select and apply the proper instruments a complete analysis of the many factors must be made.

The three basic types of instruments used for temperature measurement and control in refineries are:

(a) Thermometer or thermal bulb type.
(b) Potentiometer pyrometer or thermocouple type.
(c) Resistance thermometer or resistance bulb type.

These instruments are used to cover a wide scope of temperature applications, and each type has specific advantages for various applications. When an instrument is not properly applied, the features incorporated to overcome or compensate for certain conditions are not used to full advantage and the result may be high maintenance costs or erratic measurement and control or both. The thermal bulb type thermometers may be classified as follows:

Class I —Liquid expansion
Class II —Vapor tension
Class III—Gas filled
Class IV—Mercury filled

● **Class I—Liquid expansion.** The Class I or liquid filled system is based on the volumetric expansion of the liquid caused by a change of temperature at the sensitive element. As the expansion is uniform, the chart is uniformly graduated. In general this type of instrument has a temperature range from —150 to 500°F. and is desirable for atmospheric temperature ranges. As ambient temperature changes affect this system between the sensitive element and instrument case, this effect must be compensated for in tube systems exceeding 25 ft., although the error may be somewhat minimized by using a bulb of sufficient size to increase the capacity ratio between the bulb and system. As in nearly all thermometers, overrange protection is provided by a spring or linkage arrangement. A change in elevation, exceeding certain limits, of either the sensitive element or case requires adjustment of calibration within the case.

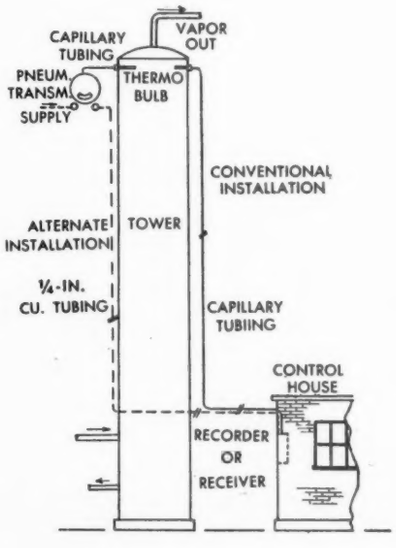
● **Class II—Vapor tension.** The Class II or vapor tension thermometer is available for ranges from — 25 to 600°F. The chart graduations are non-uniform, for the volatile liquids used in this system have gradually increasing increments of vapor pressure for uniform increments in increased temperature. This instrument may be provided with capillary tubing up to 500 ft. in length.

As a slight temperature change around the sensitive element causes a rapid increase in the vapor pressure of the filling medium, this instrument is highly desirable for applications requiring a high speed of response to controlled temperature changes.

It is recommended for applications where the operating range is held within narrow limits. The non-uniform scale inherent in this design permits large pen travel for a small temperature change, therefore, the chart range should be selected so that the operating temperatures are within the widely spaced graduations.

The vapor tension thermometer is unaffected by fluctuating temperatures along the capillary tubing thereby insuring greater accuracy. The vapor tension instrument generally embodies the smaller size bulb, which is a definite advantage on some applications.

FIG. 12



● **Class III—Gas filled.** The Class III or gas filled system is also based on volumetric expansion as is Class I and, being uniform, makes possible the use of a uniformly spaced chart. The general range of this type system is from —100 to 1000°F. or equivalent. Tubing lengths up to 200 ft. are available where ambient temperature changes are negligible and where installation space is adequate for the large size bulb. Greater lengths may be provided with compensation. The scales are divided uniformly and gas filled thermometers lend themselves to measuring temperatures that vary over the full range of the scale. With the uniform scale, temperatures and pressures that are related may be recorded on the same chart in what is known as a two-pen instrument.

● **Class IV—Mercury filled.** The Class IV thermometer is the mercury filled type. The temperature limits are from — 40 to 1200°F. The chart graduations are uniform due to the filling medium of mercury having a uniform coefficient of expansion. This instrument is available in capillary tubing lengths exceeding 200 ft. Bulb sizes are small and highly responsive. The operating system is powerful and dependable.

Generally the overall characteristics of this system are ideal because they incorporate many advantages of the other thermometer systems. Ambient temperature changes along the capillary connecting tubing are compensated by one manufacturer in the following manner: A special alloy wire is inserted within the capillary tubing with a coefficient of expansion so related to that of the tubing and mercury that any expansion or contraction of tubing and mercury due to fluctuating temperatures between bulb and instrument case is accurately counteracted.

● **General discussion.** The various classes of thermometers described above are used in many applications throughout the refinery. The simplicity of the actuating mechanism involving few moving parts and the accuracy obtained makes this an ideal instrument for recording or controlling individual temperatures. This instrument is not affected materially by local vibration.

When tubing lengths are nominal, there is a considerable savings effected as compared to the cost of a potentiometer. Obviously, care should be exercised in the selection of this equipment with respect to the practicability of the

*Alfred Krieg is supervisor of Instrument Department at Socony-Vacuum's Paulsboro, New Jersey, refinery.

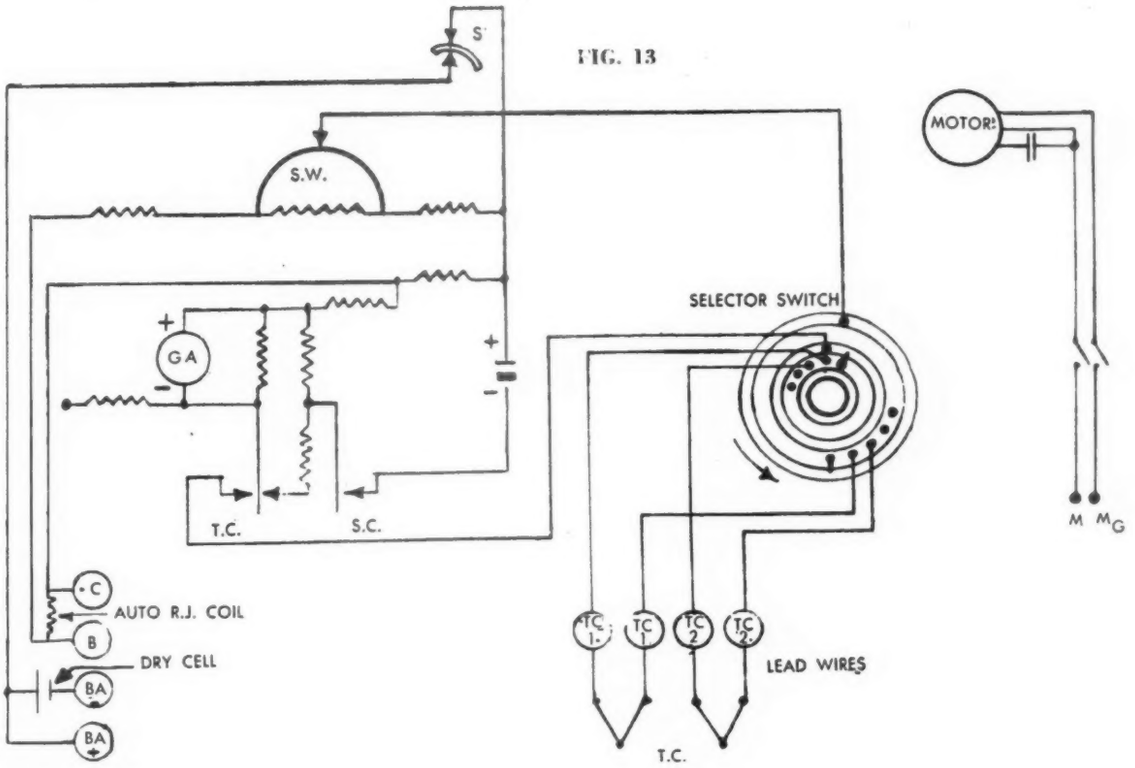


FIG. 13

bulb size and also extremely long lengths of tubing, for this materially affects the cost, particularly as applied to the mercury filled system.

The pneumatic mechanisms used in the temperature instruments described above are the "on-off," proportional and proportional reset types (as described in Part I of this series).

At the Socony-Vacuum Paulsboro Refinery, indicating and recording temperature controllers are used on applications for top tower control, reboilers, heat exchangers, chillers, time cycle or program timers, dryers, and for measuring various other liquid, steam, and gas temperatures.

On top tower and reboiler applications Class II and III thermometers are used in conjunction with proportional-reset type controllers. Heat exchangers and dryers are equipped with the Class III thermal system and on-off, proportional and proportional-reset type controllers. Chillers and time cycle applications are used with Class III and IV thermometers with proportional and proportional reset type controllers.

It must not be assumed that the above selections apply as stated in all cases, as the type and nature of the problem is always the deciding factor. This will be discussed further under process lag.

The effects of a fire in the area through which the capillary tubing passes or mechanical breakage of the tubing due to mishandling presents a serious problem, for a tube failure will render the instrument inoperative until factory repairs are made, unless complete facilities for repairing and refilling the tube system are available at the instrument department.

In Fig. 12 is shown an effective method for eliminating the above condition, namely, the application of pneumatic transmission (described in Part I) to this type of instrument. In this way conventional copper tubing is substituted for the capillary tubing. The transmitter is placed within close proximity of the sensitive bulb, thereby making it possible to utilize a bulb, tube assembly and helix with a total length of less than 6 ft., depending on local conditions. This method virtually eliminates any damage to the tube system that may be caused by a fire or mishandling as explained above, for it would only be necessary to replace the copper tubing in most cases between the transmitter and receiver. Pneumatic transmission also makes it possible to purchase complete system assemblies, thereby affording a spare unit that may be carried in the plant stock room for emergency purposes, for the elimination of the lengthy capillary tubing reduces the total cost of the system within reason. A change in the range of an existing instrument could be accomplished more readily and with less expense by the use of this method also. It is again evident that by standardizing on certain types of instruments for a given application the spare parts inventory is maintained at a minimum.

● **Potentiometer pyrometer.** The potentiometer pyrometer is the most widely used instrument for measuring and controlling temperatures in the modern refinery. This may be attributed to the fact that it is considered the most accurate and practical method of temperature measurement. There are many types and models available for various applications. Among those generally used are the:

(a) Electromechanical potentiometer
(b) Electronic potentiometer
(c) Electronic photo-tube potentiometer

● **Electromechanical potentiometer.** The electromechanical poteniometer consists essentially of a deflectional type galvanometer, slide wire, bridge resistance coils, cold junction coil, standard cell, dry cell, standardizing and balancing circuits, and necessary printing mechanism. (See Fig. 13.)

This precision type instrument is guaranteed by one manufacturer to have an overall accuracy as high as 1/5 of 1 per cent of full scale. When used with the proper thermocouple, temperatures may be measured in ranges from minus 300 to 3000°F. The minimum scale span is generally limited to 400°F. Narrower ranges would necessitate the use of a more sensitive galvanometer, which would not be practical due to local vibration effects that may be encountered in the field.

Many printing speeds are available, depending on the application involved. On multiple point recorders, 15 to 30 sec. per point is commonly used; however, when necessary, printing speeds of less than 5 sec. per point are also available.

A reasonable lead resistance from the thermocouple to the recorder does not affect the accuracy of the measuring temperature. This feature is characteristic of all potentiometer type measuring instruments. Automatic cold junction compensation and automatic standardization is available in the indicating, recording, and controlling models, and single or multiple recording. Sixteen points may be recorded on one chart. Many of these instruments are in use and they have been found to be most satisfactory for general refinery applications.

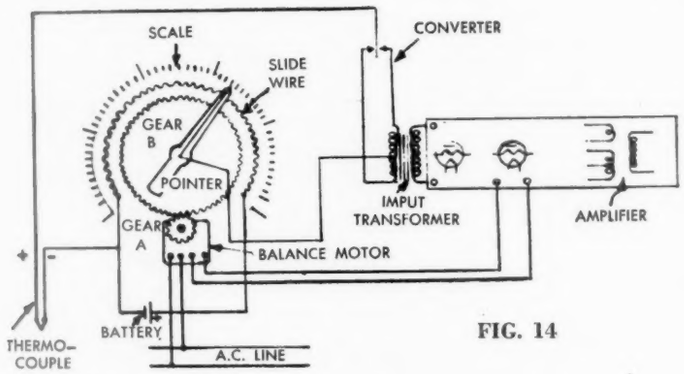


FIG. 14

● **Electronic potentiometer.** The electronic potentiometer differs in several ways from the electromechanical potentiometer. It is unique because it does not require the use of a galvanometer in the detecting circuit. The thermocouple e.m.f. is detected, converted from d.c. to a.c. and amplified, thence it is used to drive the balancing motor, thereby balancing the potentiometer circuit. (See Fig. 14.)

A calibrated accuracy within plus or minus 1/5 of 1 per cent of scale span in excess of 10 mv. and plus or minus 0.020 mv. for spans less than 10 mv. is claimed by the manufacturer.

A wide variety of printing speeds are available with this type of instrument. At the Socony-Vacuum Paulsboro Refinery, on pure column products, critical temperatures are being controlled with an accuracy of plus or minus ¼ of 1°F. by use of this narrow scale range. On these narrow scale spans, it becomes increasingly important to compensate accurately for cold junction temperature variation. This is accomplished by one manufacturer by using an auxiliary thermocouple built into the cold junction circuit.

Automatic standardizing and continuous balancing are available in the indicating, recording, and controlling types. On recorders, as many as 16 temperature records may be printed on one chart and special recorders have been supplied to record up to 144 temperatures.

Although this is a recent development in instruments, there are also many of these in use on various refinery temperature measurements.

● **Electronic photo-tube potentiometer.** Another type of electronic potentiometer employs the use of the phototube and is known as the photo-electrically balanced potentiometer. (See Fig. 15.) This method uses a galvanometer with a mirror attached to the moving coil. A light source is focused on the galvanometer mirror. Any change in the thermocouple electromotive force will cause a deflection of the mirror galvanometer and the reflected light beam is projected upon the photo-tube. A change in light intensity varies the current flow through the photo-electric tube and through suitable amplification is used to energize relays that in turn operate a reversible motor driving the slide wire to balance the unknown e.m f.

This instrument makes use of a pointerless high resistance galvanometer with a low moment of inertia and low torque. In conjunction with a long light beam, this results in high sensitivity and therefore greater accuracy. The manufacturer asserts recording accuracy of 1/10 of 1 per cent and various printing speeds from 30 sec. per temperature point to 3 sec. per temperature point. The standard multiple point instrument scale is traversed in 45 sec.; however, faster speeds are available.

Long extension lead lengths may be used without materially affecting the instrument accuracy due to the sensitivity of the galvanometer. Cold junction is automatically compensated and standardizing current is recorded.

Twelve temperatures may be recorded on one chart. Indicating controllers are available for controlling as many as 6 temperatures within one instrument.

● **Thermocouples.** In refinery applications, the types of thermocouples most commonly used are the iron constantan and the chromel alumel. These thermocouples are known as the base metal type and have been selected as being nearly ideal for specific reasons, namely:

1. Their capacity for resisting corrosion, oxidation, reduction, and crystallization.
2. Development of a comparatively large electromotive force.
3. A temperature e.m.f. relationship such that the e.m.f. increases fairly uniformly with increasing temperature.
4. Cost.
5. Reproducibility.

It is recommended that the iron constantan thermocouple shall not be used where operating temperatures will exceed 1400°F. except for intermittent use during short time intervals. The iron constantan thermocouple is also recommended for use where reducing atmospheres are present.

The chromel alumel thermocouple is suitable for temperatures not exceeding 1800°F. except for intermittent use. It is recommended for oxidizing atmospheres.

● **Protecting tubes.** Obviously, after proper thermocouple selection has been made, it becomes of equal importance to select a suitable protecting tube, for the life of the thermocouple is dependent to a considerable extent on the proper method of protection. The necessary requirements for determining a suitable protecting tube are:

1. Resistance to high temperatures.
2. Resistance to the action of oxidizing and reducing gases.
3. High thermal conductivity insuring prompt transmission of changes in temperature.
4. Resistance to sudden changes in temperature.
5. Ability to withstand mechanical shocks and strains.
6. Resistance to corrosion and erosion.

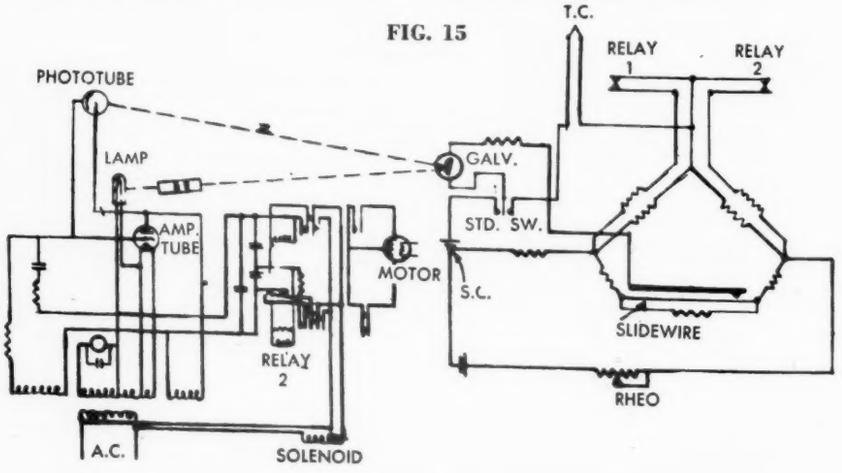
● **Extension leads.** Extension leads do not compensate, but extend or move the thermocouple cold junction from the thermocouple to the instrument. Changes in ambient temperature at the instrument are then compensated for by various means within the instrument, this method being known as automatic cold junction compensation.

The primary requirement of extension lead wire is that it match electrically the e.m.f. characteristics of the thermocouple within the temperature range to which lead wire terminals may be exposed.

Iron constantan and chromel alumel couples each require a specific kind of lead wire. Any deviation from this practice will result in serious errors in temperature measurement.

It therefore becomes obvious that extension lead wire should be purchased from reliable sources, for inaccuracies in the composition will reflect in the temperature being measured.

FIG. 15



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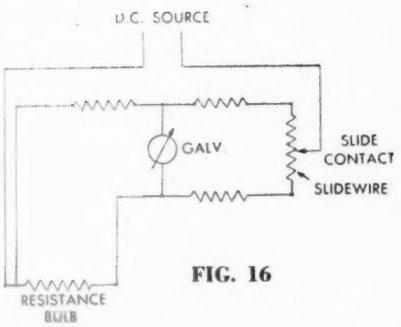


FIG. 16

● **Resistance thermometers.** The resistance thermometer is another method for measuring and controlling temperatures and it is particularly well adapted to the accurate measurement of low temperatures.

Although the basic principle used by the instrument manufacturers for the measurement of temperature by the resistance thermometer method is essentially the same, various arrangements are used for circuit balancing. Two methods will be described:

(a) Mechanically balanced resistance thermometer.

(b) Electronically balanced resistance thermometer.

● **Mechanically balanced method.** The mechanically balanced resistance thermometer using the null balance Wheatstone bridge principle is well adapted to precision temperature measurements of minus 300 to plus 300°F. (See Fig. 16.)

The Wheatstone bridge circuit consists essentially of three fixed resistors (one being in the slide wire circuit for calibration purposes) a nickel or platinum resistance bulb and slide wire as the variable resistance. An increase in the bulb resistance due to a temperature rise is balanced by the change in resistance of the increased length of the slide wire.

Cold junction compensation and the standard cell are not required in this circuit.

When used with platinum resistance bulbs, temperatures as high as 1500°F. may be measured. Narrow scale spans of 25°F. are also available.

The three wire circuit is used between the resistance bulb and the instrument to prevent measuring errors due to temperature changes along the connecting wires. These copper wires represent one junction of the bridge circuit, and therefore temperature variations will cancel out.

The recording mechanism is similar to that of the electromechanical potentiometer.

This type of instrument is used for recording and controlling low temperatures such as refrigeration, for chiller units in oil dewaxing, measurement of operating temperatures in large generator field windings, measurement of differential temperatures in refrigeration systems, and controlling low temperature on reboilers, condensers, and fractionating columns.

● **Electronically balanced resistance thermometer.** Another electronically balanced temperature recorder consists of a form of the Wheatstone bridge circuit, and uses a resistance bulb as the temperature sensitive element. This method of measurement is unusual inasmuch as resistors and capacitors are employed in the bridge circuit. (See Fig. 17.)

The electrical resistance of the sensitive bulb varies with changes in the temperature of the fluid around it. This resistance is measured by comparison with a fixed resistor in a bridge measuring circuit. The 2 other elements in the bridge circuit are a fixed capacitor or condenser, and a variable capacitor that has two stacks of intermeshed metal plates insulated from each other. This variable capacitor is adjusted in the same way radios are tuned by turning one of the stacks of plates (called the rotor) to change the amount of intermeshing.

Points 2 and 4 of the bridge are connected to a source of low voltage alternating current. As the resistance of the bulb or element changes, the voltage at point 1 changes. The voltage at point 3 can be varied by changing the position of the rotor of the balancing capacitor and, by adjusting the rotor to make the voltages at 1 and at 3 equal, the voltage difference between these points is reduced to zero. This adjustment of the bridge is called "null balance" and when this exists the position of the capacitor rotor can be calibrated to read the resistance of the sensitive bulb. The recording pen is driven by a mechanical link from this rotor.

Points 1 and 3 are connected to an electronic unit. This unit adjusts continuously the position of the rotor of the variable capacitor to hold the bridge in null balance adjustment. As the sensitive bulb resistance changes, the rotor is held at the position to keep the bridge circuit in balance and so the pen records continuously the temperature at the sensitive bulb.

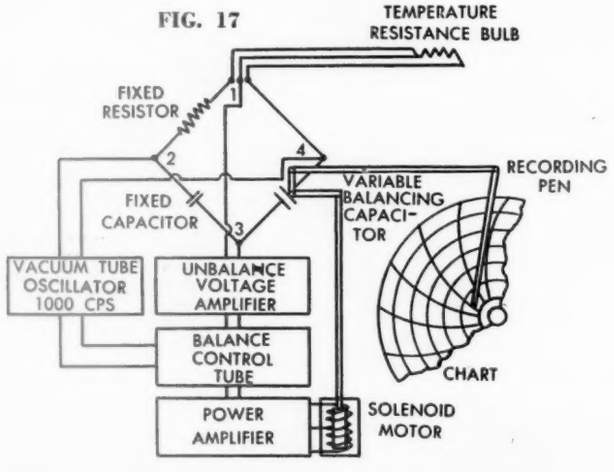
The instrument has unusually high sensitivity and has definite balancing action on unbalance voltages of less than 15 microvolts. The balancing mechanism completely eliminates the usual slide wire and galvanometer mechanism and pen travel across the circular chart requires only 3 sec. This instrument is available in ranges of —300 to 600°F.

For special applications the instrument may be adjusted to expand any part of a given temperature range, so that complete pen travel across the chart may be obtained for a 4°F. temperature change. Temperature changes are simplified by changing resistors easily accessible within the case.

By the use of 2 resistance bulbs, differential temperature may be measured and recorded, and the same instrument by use of wire resistance gages may be used for measuring strain. The manufacturer claims a calibration accuracy of ¼ of 1 per cent for all ranges. This unique method of measurement is a recent development and is at this time available only in the indicating and recording type instrument.

● **Resistance bulb.** The resistance bulb is the sensitive element used for measuring temperatures by resistance thermometer methods. The most commonly used resistance bulbs for temperatures below 300°F. are wound of nickel or copper wire. For temperatures above 300°F. platinum resistors are used. These materials are selected due to their respective high temperature coefficients of electrical resistance characteristics. Other essential requirements are permanence of calibration and sensitivity of response. These bulbs are manufactured with an accuracy of 0.05°F. in the lower

FIG. 17



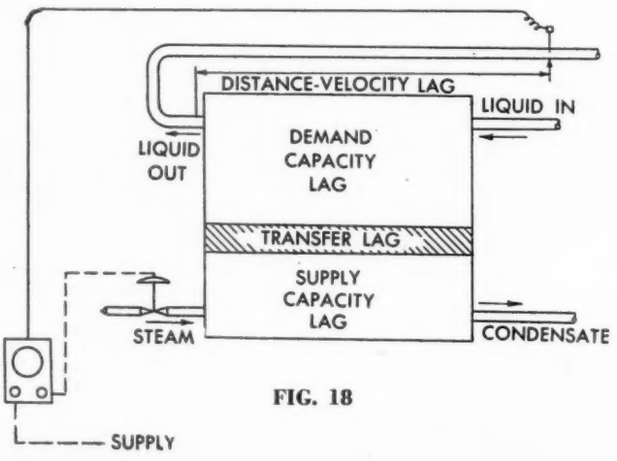


FIG. 18

Thinking it Through

(No. 1 OF A SERIES)

Proposition

Earning power – not first cost – measures the difference in Fluid "Cat-Cracker" designs

The Facts

Once they're up, all *Fluid* catalytic-cracking units could easily pass for first cousins.

It isn't until the cost accountant has posted their operation records in the profit and loss columns that the very real differences in their characteristics can be appreciated—differences that eliminate initial cost as a reliable basis of comparison.

One of the truer measures of value in comparison of units with equal capacities is the "on-stream" efficiency achieved by the design. For here a difference of only one shutdown can mean a plus-or-minus in throughput revenue of $200,000.00 or more per year in a plant of moderate size.

In this respect, the current average on-stream efficiency of *all* Kellogg *Fluid* "cat-crackers"—89.4%—assumes vital significance. Kellogg customers report, further, that continuous on-stream time can be, and in fact has been, progressively increased in length to well over a year.

There are reasons aplenty for this new record in on-stream efficiency. First, Kellogg pioneered the commercial application of the *Fluid* catalyst principle. Second, Kellogg has designed and built over two-thirds of the world's *Fluid* catalytic-cracking capacity. Third, this cumulative experience has spurred continuous design improvements. The continuing revenue which these improvements achieve through stepped-up efficiency far outweighs their initial cost.

Conclusion ------ **There is no substitute for the best design**

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ranges and 0.5°F. accuracy in the higher ranges. They are generally used in protecting wells, particularly when exposed to pressure or where there is danger of mechanical injury.

● **Process variables.** In all process control applications, variables are present to a greater or lesser extent, and in order to illustrate the conditions, a graphic analysis of control variables is shown in Fig. 18, this being similar to the method used by E. D. Haigler[1].

Process lag is a term applied to a group or number of generally unfavorable process characteristics. There are, generally, 3 types of process lag: (a) Capacity lag, (b) transfer lag, and (c) distance velocity lag.

Capacity lag may be defined as a process lag that results in the retardation of detection of a change in the *value* of a variable due to energy or material capacity.

Transfer lag is a retardation of the conditions of a given process variable following an instantaneous *change* of some related variable resulting from resistance offered to flow of energy between 2 or more reasonably isolated capacities of the process.

Distance velocity lag is defined as a delay in *detection* of a change in the measured value of the variable due to the need to transport material to the point of measurement.

Fig. 18 represents schematically a countercurrent heat exchanger with a liquid to be heated passing through the upper section, and the heating medium passing through the lower section. These sections are separated by a wall or partition.

The sensitive element of the temperature controller is situated in the heated liquid outlet of the exchanger, and the control valve in the steam inlet or heating supply to the exchanger. A diagrammatical analysis of capacity lag, transfer lag, and distance velocity lag are shown in the figure.

● **Capacity lag.** In any process, whether it be batch, semi-continuous or continuous, storage capacity, either as fluid volume or heat content, constitutes the equivalent of a balance wheel by its tendency to keep the system in equilibrium. In general, the predominant effect of all storage capacity is favorable as regards instrumentation.

Storage capacity may be of 2 types, namely, demand side capacity and supply side capacity. The demand side is generally referred to as having a favorable stabilizing influence. The mass of material being heated is referred to as the demand side and the mass of heating medium as the supply side. It is possible for a large supply side storage capacity to become an unfavorable factor if the rate of heat input to the system exceeds the heat absorption rate of the material being heated.

As a comparison between large and limited heat storage capacity, consider the difference between holding a constant temperature on a flowing liquid as illustrated in Fig. 19 and that of holding a constant temperature on a flowing liquid as in Fig. 20. In Fig. 19, a fixed volume is flowing into the vessel and an equal volume flowing out. Heat is applied to the vessel and the temperature of the liquid is measured by a thermometer bulb. A high velocity heat exchanger is substituted in place of the vessel in Fig. 20. The heat exchanger has a comparatively small volume of liquid in the tubes at any one time, although the rates of flow are identical to those in Fig. 19.

In Fig. 19, it is evident that uneven firing of the vessel, slight changes in the rate of flow, or sudden changes in atmospheric conditions will not seriously affect the controlled temperatures, as the mass of liquid exerts a stabilizing influence on the system and will tend to iron out variations caused by any of these variables.

FIG. 19

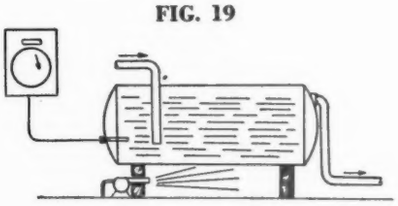


FIG. 20

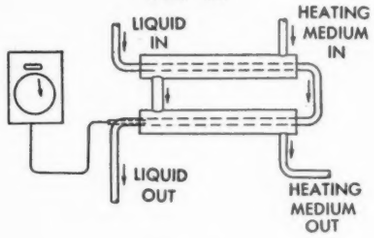


FIG. 21

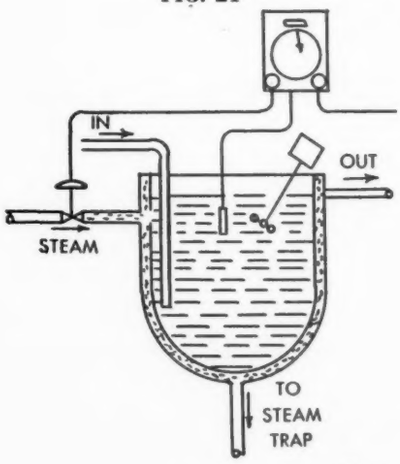
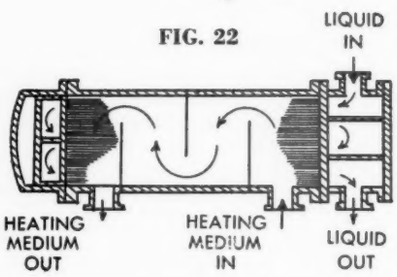


FIG. 22



In Fig. 20, the stabilizing influence is not available, and the volume of liquid in the exchanger at any moment is small in comparison to the rate of throughput. Small variations in the rate of flow or heat supply will be immediately reflected in the temperature measuring instrument and constant vigilance by the operator is required to hold temperatures constant in such a system.

Supply side storage capacity may become an unfavorable factor, if the rate of heat input exceeds the rate of heat absorption of the material being heated. As an example of temperature control application, consider a steel heat-treating furnace in which the furnace brickwork heat storage capacity is large compared with the stored heat capacity of the metal being treated. If the burners are adjusted so that the heat input rate is materially higher than the absorption rate of the metal being treated, the brick work will absorb the heat faster than the metal. As a result, the controlled temperature will tend to overshoot the desired value. A problem of this type may be solved by controlling the rate of heat input to correspond more closely with the rate of heat absorption.

● **Transfer lag.** Transfer lag or time lag has an equally important effect on the controllability of a system. Generally, the shorter the transfer lag the simpler the problem of control. It must not be assumed, however, that problems with a minimum of process lag can always be solved by application of the simplest types of control mechanisms, because lag must be weighed with capacity and other effects, which will be discussed later in this article.

One of the simplest cases, illustrated in Fig. 21, shows a common type of steam-jacketed vessel with a large liquid storage capacity. Unless a mechanical stirring device is used to keep the liquid in motion, heat is transferred from the steam jacket to the center of the vessel by conduction only.

By using the stirring device the rate of heat input is accelerated by the added effect of convection heat transfer. The actual time lag in transferring heat to the center of the mass will be dependent on (a) the conductivity of the liquid, (b) the rate of stirring or agitation, (c) the amount of heating surface in relation to the mass of liquid being heated, (d) the temperature differential between the steam and the liquid, (e) cleanliness of the vessel surface, sometimes termed "fouling" factor, and several other factors of equal importance.

Obviously, some of these transfer lags can be reduced by having the mass of the liquid small in relation to the amount of heating surface, but by so doing the stabilizing effects of stored heat capacity are lost. A standard tubular type countercurrent heat exchanger is a good example of a heating system with a high rate of heat input, but with small storage capacity. (See Fig. 22).

This illustrates the simplest form of transfer lag. The factors influencing the amount of transfer or time lag are essentially the same as those outlined

[1]E. D. Haigler. *ASME Transactions*, November, 1938, pp. 633-640.

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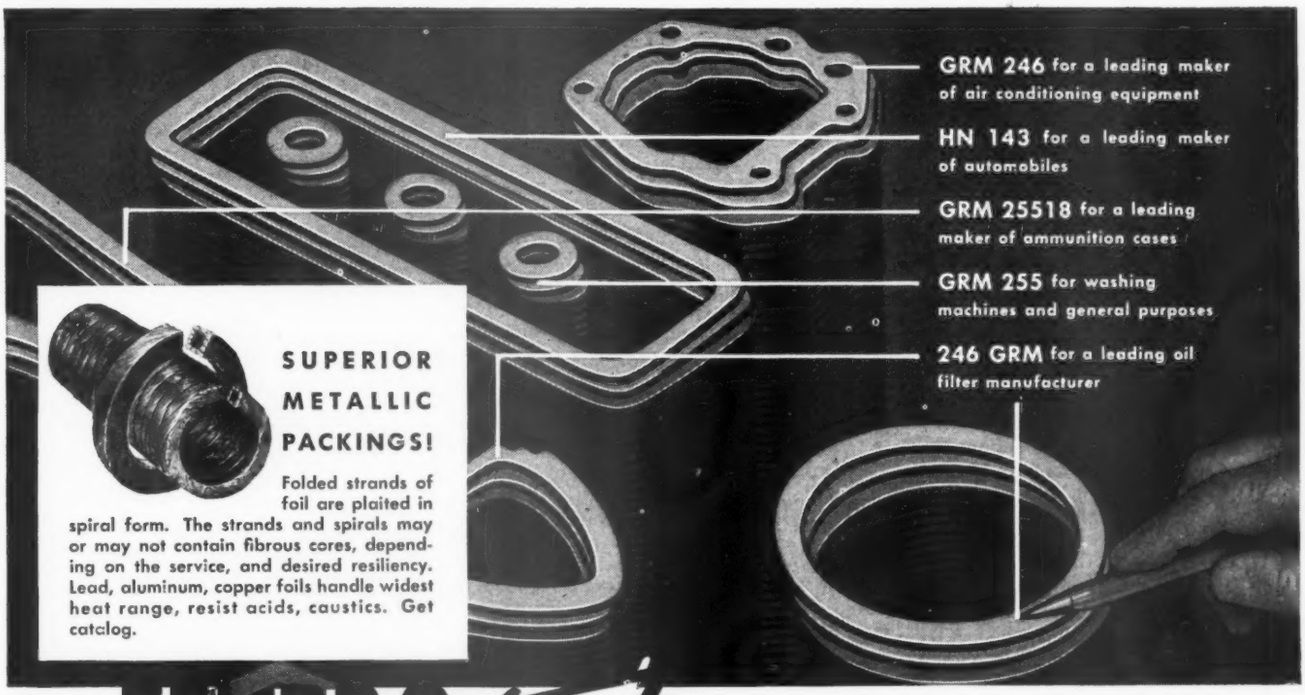
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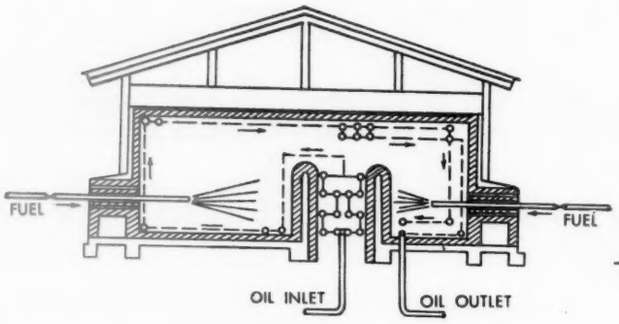


FIG. 23

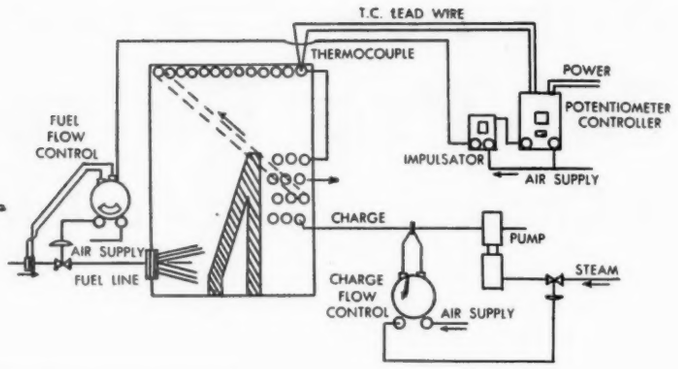


FIG. 25

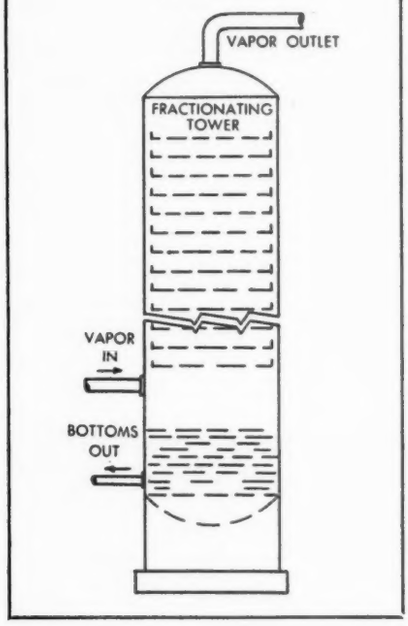
above, namely: (a) The conductivity of the liquid, (b) temperature differential between heating medium and liquid, (c) conductivity of the heat exchanger materials, (d) velocity of flow of both mediums and other factors peculiar to the particular design of the equipment. In general, the transfer or time lags will be smaller in this type of equipment than in those shown in Fig. 21.

● **Distance velocity lag.** Fig. 23 illustrates another type of lag, the distance-velocity or transportation lag. This figure shows a tubular type of furnace commonly termed a heater in petroleum refineries. Oil is pumped through this heater at a constant rate of flow. Hundreds of feet of tubing are contained in the heater, and the flow is generally in series with a maximum velocity of 6 to 12 ft. per sec. An appreciable time is required for a molecule of oil to pass through the heater tubes. If every ordinary variable, except the inlet temperature, was for the time constant there would be a lag in the recording of an inlet temperature change if the bulb or thermocouple were placed in the outlet or transfer line. If the outlet temperature is being controlled, the change of inlet temperature must be transported to the sensitive element in the outlet before the control system can start balancing to the new temperature or load conditions.

In some classes of heat transfer equipment the velocities cannot be increased beyond predetermined maximum limits. Fig. 24 is an example of this condition and shows a fractionating column commonly used in the chemical and distilling industries. Columns such as this are simply exchangers in which heat is absorbed and given up through a series of trays by condensation and evaporation rather than by flow through tubes. Vapor velocities are generally low and cannot be increased without the sacrifice of fractionating efficiency. Changes in temperature of the inlet vapors may take minutes to reflect to the top of the column sensitive element, depending on the type and number of trays. In such equipment, load changes must be held to a minimum to obtain satisfactory control.

● **Thermal potential.** The use of higher thermal potentials is an important factor in reducing the size of heat transfer equipment, as the rate of heat transfer from one medium to another is proportional to the thermal differential. A liquid may be heated faster by using a flame

FIG. 24



temperature than by heating with the steam jacket, as shown in Fig. 21. As another example, the steam jacketed vessel may be heated faster using high pressure or high temperature steam than with low pressure or low temperature steam.

All factors being equal, it may be stated that the greater the thermal potential between supply and demand, the more difficult the problem of control. Similar effects are also the result of improperly sized control valves, and in either case it becomes a problem of extremely accurate positioning of the control valve to accommodate a specific load change.

Magnitude of load change is of importance only as it affects the size of the control valve or the controlling mechanism.

Rates of heat absorption or of stabilization determine the adjustments of the controller (throttling or automatic reset) and are therefore the criteria for tuning a controller with any given control system.

Rates of load change determine the degree of complexity of the control problem and are an important factor in determining the type of control equipment best suited to the service or application.

Summing up the foregoing discussion. it can be stated that the most difficult control problem we can have would be one that had a minimum of storage capacity, a maximum of transfer lag, a high thermal potential in the heat transfer system, and an oversized control valve.

● **Furnace outlet control.** In some processes, control conditions are such that it is not possible to get satisfactory automatic control in the usual direct manner. Unfavorable lag conditions make it necessary to adjust the control instruments for very slow action, but conditions other than lag necessitate rapid valve action. This may be accomplished by the use of one controller setting the control of a second controller instead of controlling the valve directly.

For instance a temperature controller will set the control point of a flow controller controlling the fuel input, or a level controller will set the control point of a flow controller controlling the flow from a pressure vessel. A pipestill is a good example of this type of process.

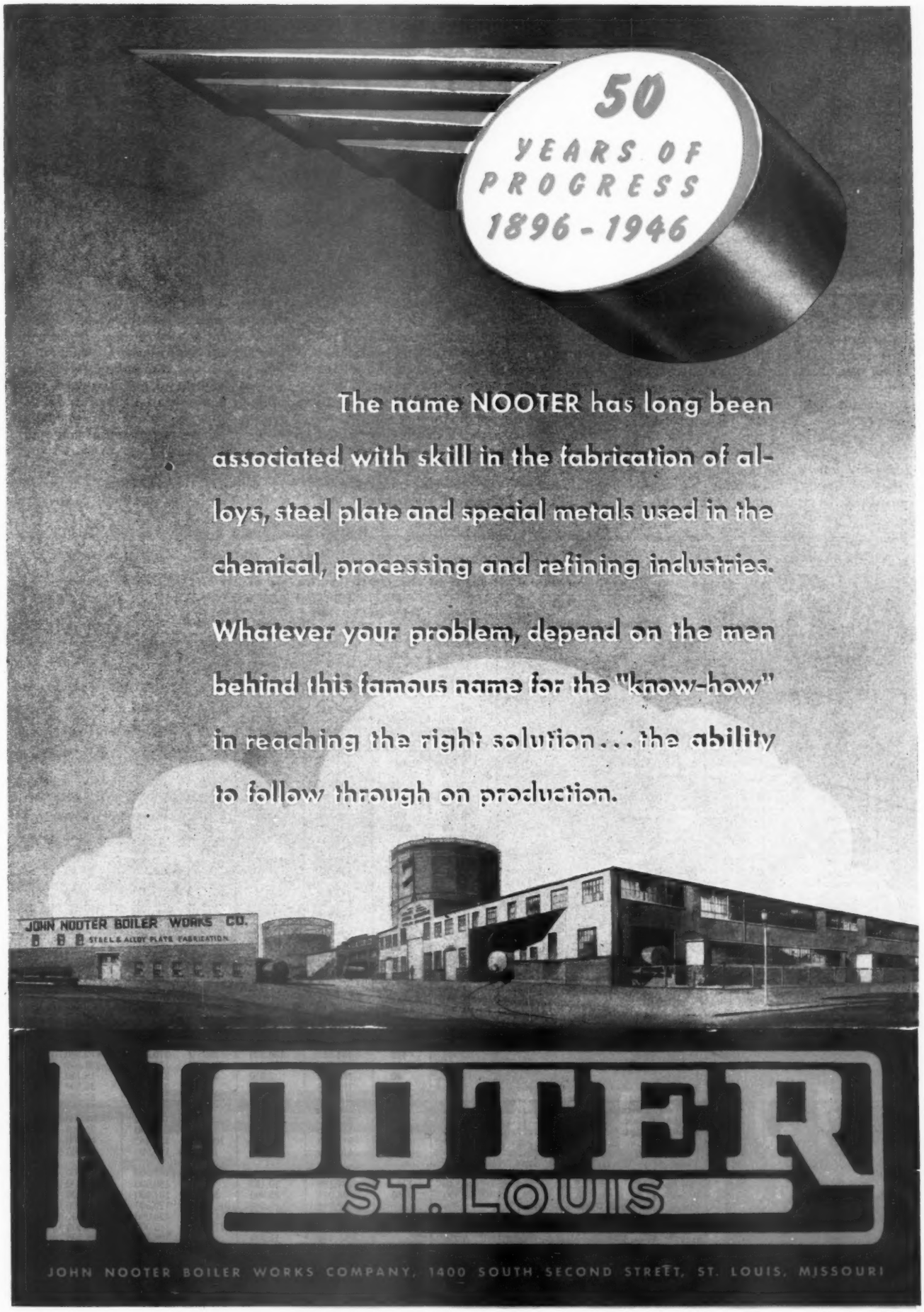
See Fig. 25. The instrument controlling the fuel supply is selected so that very little lag exists with respect to its function. With oil or gas fuel a flow controller proportions the fuel input independent of all external influences. This instrument can be adjusted to move the control valve as rapidly as necessary to maintain constant fuel conditions.

As the temperature is the final variable that must be controlled, it is also necessary to adjust the fuel supply to meet the temperature demands. For this a potentiometer is used that controls the control point of the fuel flow controller. Freed from the task of controlling outside upsetting conditions, the potentiometer can be adjusted to as slow action as lag conditions require.

To combat transfer lag further, an impulsator may be used. It amplifies the operating air pressure change from the potentiometer controller.

This system not only gives exceedingly close temperature control under normal conditions, but it also gives complete control under all conditions. An abnormal unbalanced condition will be rectified quicker with this method of control.

Editor's Note: **This series of articles by Mr. Krieg will be continued in an early issue.**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ACRE-FOOT RECOVERIES FROM OIL FIELDS

By **S. F. SHAW,** Consulting Mining and Petroleum Engineer

PART 1

EXCLUSIVE

It is well understood that the content of fluid contained in a reservoir depends upon the area, thickness, and porosity of the producing formation. These factors are never accurately known because the borders of oil fields are irregular, and thickness and porosity are never uniform; and there is no practical means of determining them accurately. Some approach to an acceptable figure for these factors can be determined, however, depending upon the care with which they are measured.

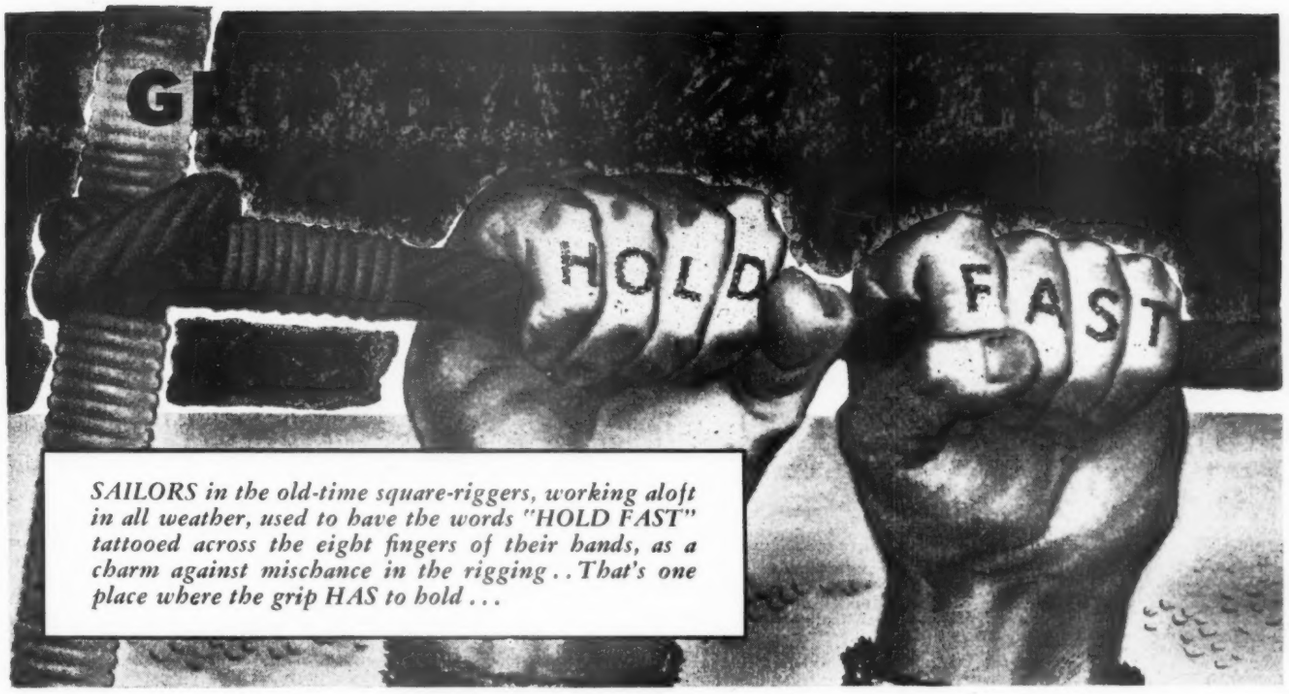
The quantity of oil extracted from a reservoir can be stated in unit measurement by dividing the number of barrels recovered by the acreage, and this is probably the most useful unit in use. It is also the easiest to determine, because figures for production and acreage are nearly always available. This factor does not allow any estimate to be made of the contents of the reservoir, however, nor does it serve to make an estimate of the probable ultimate recovery, for it does not take into account the thickness of the producing sand. Another unit, therefore, is necessary and this is determined by dividing the production per acre by the thickness of the formation, which unit is called the "barrels per acre-foot." A unit for barrels of oil per acre-foot per per cent porosity may eventually come into use, which will provide more accurate estimates, but we are not yet ready for such a unit in general practice.

The contents of pipe line oil in the reservoir is dependent upon additional factors, as follows: Free gas in the upper portion of the reservoir, water in the lower portion, percentage of connate water, quantity of gas dissolved in the oil, and temperature of the oil. All these factors must be taken into account in order to arrive at the actual contents of oil in the reservoir as measured under standard surface conditions. The determination of these factors is important, and yet it is very difficult to ascertain

TABLE 1

Data on production from the principal oil fields of the United States. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	East Texas	1930	Woodbine	136,000	35	1,960,512	14,410	412	4,500,000	33,100	946
2	Long Beach	1921	Pico, Repetto, Puente	1,600	1650	688,194	430,000	261	790,000	493,000	290
3	Midway	1901	Etchegoin, Maricopa	33,000	65	669,321	20,000	307	1,160,000	35,100	543
4	Oklahoma City	1928	Simpson, Wilcox, Arbuckle	15,500	....	602,676	40,000	....	708,320	45,700	....
5	Santa Fe Springs	1919	Repetto, Puente	1,630	1360	492,234	302,000	222	550,000	337,400	248
6	Bradford	1871	First, Second, Chipmunk; Fourth, Kane Haskell	84,000	....	460,687	5,520	....	665,000	7,920	....
7	Smackover	1922	Nacatoch, Groves, Tokio	25,760	36.2	398,933	15,500	428	435,000	16,900	468
8	Coalinga	1900	Etch, Temblor, Plio, Mio, Avenal	22,925	199	436,585	19,100	99	850,000	38,500	193
9	Cushing	1912	Layton, Jones, Prue, Skinner, Red Fork, Bartlesville	24,940	....	365,417	14,700	....	399,620	16,000	....
10	Huntington Beach	1920	Repetto, Puente	2,200	1200	326,208	148,000	123	440,000	200,000	167
11	Salt Creek	1908	Frontier, Dakota, Lakota, Tensleep	21,450	....	308,391	14,350	....	365,000	17,000	....
12	Buena Vista	1909	San Joaquin, Plio, Etchegoin	22,000	50	292,722	13 300	266	350,000	15,910	318
13	Kern River	1899	Kern River, Plio	6,700	130	283,449	42,300	326	310,000	46,300	357
14	Yates	1926	San Andres	20,000	100	275,188	13,750	137	671,700	33,580	336
15	Kettleman Hills	1928	Temblor, Avenal, Mio, Eoc	16,720	850	280,506	16,800	20	430,500	25,600	30
16	Ventura Ave	1916	Pico, Repetto	2,060	3000	267,990	13,000	43	435,000	211,000	70
17	Glenn Pool	1906	Bartlesville, et al	15,970	....	223,814	13,950	....	277,000	17,340	....
18	Burbank (old)	1920	Layton, Burbank	24,665	60	211,770	8,550	142	254,300	10,300	172
19	Hendrick	1926	Seven Rivers	12,200	....	206,419	16,900	....	233,000	19,100	....
20	Healdton	1913	Upper Penn, Glen, Healdton, Ordovician	7,550	....	195,989	26,000	....	225,120	29,800	....
21	Eldorado, Kan	1917	Admire, Lansing, Bronson, Viola, Simpson, Arbuckle	25,000	....	187,202	7,500	....	211,300	8,450	....
22	Wilmington	1935	Repetto, Puente, Plio, Mio	4,400	420	207,829	47,200	112	500,000	113,500	270
23	Brea Olinda	1889	Repetto, Puente	1,680	800	175,846	104,500	131	200,000	119,000	149
24	Salem, Ill	1938	Bethel, Aux Vases, Rosiclare, McClosky, Salem, Devonian, Trenton	9,270	....	177,241	19,100	....	214,200	23,100	....
25	Elk Hills	1919	San Joaquin, Clay-Etch, Stevens, Pli, Mio	10,000	75	167,474	16,700	223	385,000	38,500	513
26	St. Louis, Okla	1927	Dolomite, Simpson, Wilcox	19,905	....	163,051	8,200	....	185,500	9,320	....
27	Caddo	1905	Nacatoch, Saratoga, Tokio, Paluxy, Ferry River, Rodessa, Sligo	60,000	65±	157,829	2.620	41	182,500	3.040	47
28	Conroe	1931	Cockfield	17,660	30	161,943	9,180	306	700,000	39,600	1320
29	Domingues	1923	Repetto, Puente	1,200	1460	147,298	122,500	84	220,000	183,500	125
30	Van	1929	Woodbine	4,520	129	139,113	30,700	238	440,010	97,500	756
31	Inglewood	1924	Pico, Repetto, Puente, Monterey	1,075	975	139,345	129,500	133	175,000	163,000	168
32	Montebello	1917	Repetto, Puente	1,750	800	135,138	77,000	96	160,000	91,500	115
33	Seminole City	1926	Hunton, Wilcox	4,635	....	132,648	28,600	....	174,810	33,400	....
34	Coyote, West	1909	Repetto, Pli	985	473	133,651	135,000	287	170,000	172,500	364
35	Spindletop	1901	Cap, Mio, Frio, Olig	500	69	127,393	255,000	3720	131,700	263,400	3820
36	McElroy	1926	Grayburg	14,000	40	133,179	9,510	238	226,000	16,150	404
37	Earlsboro	1926	Earlsboro, Hunton, Wilcox, Simpson	5,235	....	127,588	24,300	....	218,000	26,500	....
38	Humble	1904	Cap, Mio, Olig, Yegua, Eoc	2,350	200±	128,363	54,700	274	135,000	57,500	287
39	Tonkawa	1921	Endicott, Tonkawa, Wilcox	3,695	....	122,466	32,100	....	128,600	34,800	....
40	Bowlegs	1926	Hunton, Wilcox	4,000	30	122,733	30,680	1023	136,850	34,200	1140
41	Little River	1927	Hunton, Wilcox, Cromwell	4,090	....	115,145	28,100	....	143,680	26,200	....
42	Powell	1923	Woodbine	2,600	40	112,249	43,200	1080	121,480	46,700	1167
43	Torrance	1922	Puente, Mio	6,200	120	110,049	17,800	148	135,000	21,800	182
44	Howard-Glasscock	1926	Yates, Seven Rivers, Grayburg, San Andres	13,500	24.6	109,112	8,100	329	163,000	12,100	490
45	Hobbs	1928	San Andres	10,240	124	104,179	10,150	82	160,000	15,600	126
46	Mexia	1912	Woodbine	3,920	50	98,904	25,200	504	104,200	26,600	532
47	Big Lake	1923	Queen, San Andres, Work, Ellenburger	4,600	....	99,358	21,700	....	129,300	28,100	....
48	Richfield	1919	Puente	1,370	510	97,331	71,000	139	126,000	92,000	180
49	Hull	1918	Cap, Mio, Olig, Yegua, Cook Mt	875	63	97,952	111,500	1770	115,000	131,400	2086
50	Fitts	1933	Hunton, Viola, Bromide, McLish, Wilcox	5,955	....	98,486	16,500	....	108,750	18,200	....
51	Louden	1937	Cypress, Point Creek, Bethel, Devonian	20,650	37.1	101,336	4,910	132	195,500	9,470	255
			Total 51 fields	761,830	....	13,076,026	17,169	....	20,445,900	26,800	....
			Total 35 fields	497,835	103.9	9,482,858	19,200	185	16,058,740	32,300	311



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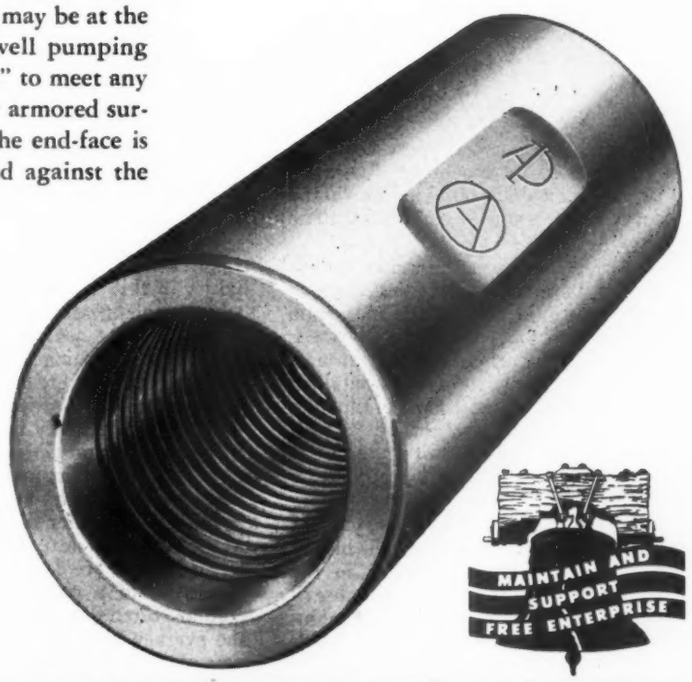

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TABLE 1-A

Data on production from some newer fields estimated at 100 million or more. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Slaughter	1936	San Andres	65,000	32	25,779	400	13	471,320	7,240	220
2	Wasson	1936	San Andres	55,000	50	54,949	990	20	453,550	8,250	164
3	Tom O'Connor	1934	Frio, Olig	12,000	175	46,684	3,890	22	400,000	33,300	190
4	Eunice-Monument	1928	Grayburg, San Andres	49,240	80.7	136,402	2,770	34	371,000	7,520	93
5	Goldsmith-Harper	1933	San Andres	28,000	58.6	55,058	19,660	336	383,710	13,650	233
6	Hastings	1934	Frio, Olig	5,800	200	63,545	10,900	55	370,000	63,800	319
7	Webster	1937	Frio, Olig	4,000	150	24,071	6,020	40	350,000	87,500	583
8	Anahuac	1935	Frio, Olig	7,000	60	32,570	4,650	78	290,000	41,400	690
9	K. M. A.	1931	Strawn, Ellenburger	36,000	25.8	57,623	1,600	62	280,000	7,800	301
10	West Ranch	1938	Het, Marg, Frio, Olig	10,000	24	17,882	1,800	75	238,000	23,800	995
11	Thompsons	1931	Mio, Frio, Olig, Vicksburg	6,515	95	56,697	8,700	92	225,000	34,500	365
12	Cowden-Foster	1930	Grayburg	40,930	41.2	49,727	1,215	30	214,500	5,730	139
13	Hawkins	1940	Sub-Clarksville, Woodbine	8,500	160	21,138	2,520	16	200,000	23,500	147
14	Magnolia	1938	Cotton Valley, Reynolds	4,414	100	30,714	6,930	70	150,000	34,000	340
15	Penwell-Jordan	1930	San Andres	11,820	25.2	31,607	2,680	106	166,510	74,100	560
16	South Ward	1928	Queen, Yates, Seven Rivers	17,700	43	49,764	2,700	63	145,070	8,190	190
17	Seminole, Texas	1937	San Andres	12,500	90	8,197	660	7	111,000	8,800	96
18	Cut Bank	1932	Cut Bank, Kootenai	38,000	30	36,858	940	31	116,000	3,050	102
			Total	412,419	59.8	799,265	1,930	32	4,935,660	11,950	200
			From Table 1	761,830		13,076,026			20,600,100		
			Total	1,174,249		13,875,281	11,800		25,535,760	21,700	

TABLE 2

Production from older principal fields of the United States. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Smackover	1922	Nacatoch, Graves, Tokio, Meakin	25,760	36.2	398,651	15,500	428	435,000	16,900	467
2	Burbank	1920	Layton, Burbank	24,665	60	211,770	8,590	143	254,370	10,310	172
3	Caddo	1905	Nacatoch, Paluxy, Saratoga, Ferry Lake Tokio, Sligo	60,000	65	157,829	2,630	40	182,500	3,040	47
4	Spindletop	1901	Cap, Mio, Frio	500	69	127,393	254,800	3690	131,700	263,400	3820
5	Humble	1904	Cap, Mio, Olig, Yegua	2,350	200	128,363	54,600	273	135,000	57,400	287
6	Bowlegs	1926	Wilcox	4,000	30	122,733	30,680	1023	136,850	34,210	1140
7	Powell	1923	Woodbine	2,600	40	112,249	43,200	1080	121,480	46,720	1168
8	Hobbs	1928	San Andres	10,240	124	104,178	11,740	95	160,000	15,620	126
9	Mexia	1920	Woodbine	3,920	50	98,904	25,200	504	104,200	26,600	532
10	Hull	1918	Cap, Mio, Olig, Yegua, Cook Mt.	875	63	97,952	111,500	1770	115,000	131,400	2086
			Total	134,910	63.5	1,560,023	11,570	182	1,776,100	13,170	208

them accurately, nevertheless, to arrive at any reasonably acceptable figure for recovery percentage obtained or obtainable, it is necessary to employ all these figures.

In various instances the writer has endeavored to ascertain what method of extraction would recover the maximum production of oil, and his experience leads him to the conclusion that in most instances maximum recovery is obtained with close spacing and with production at maximum capacity, but he finds it difficult to prove by definite figures acceptable to all that there is no question in the matter.

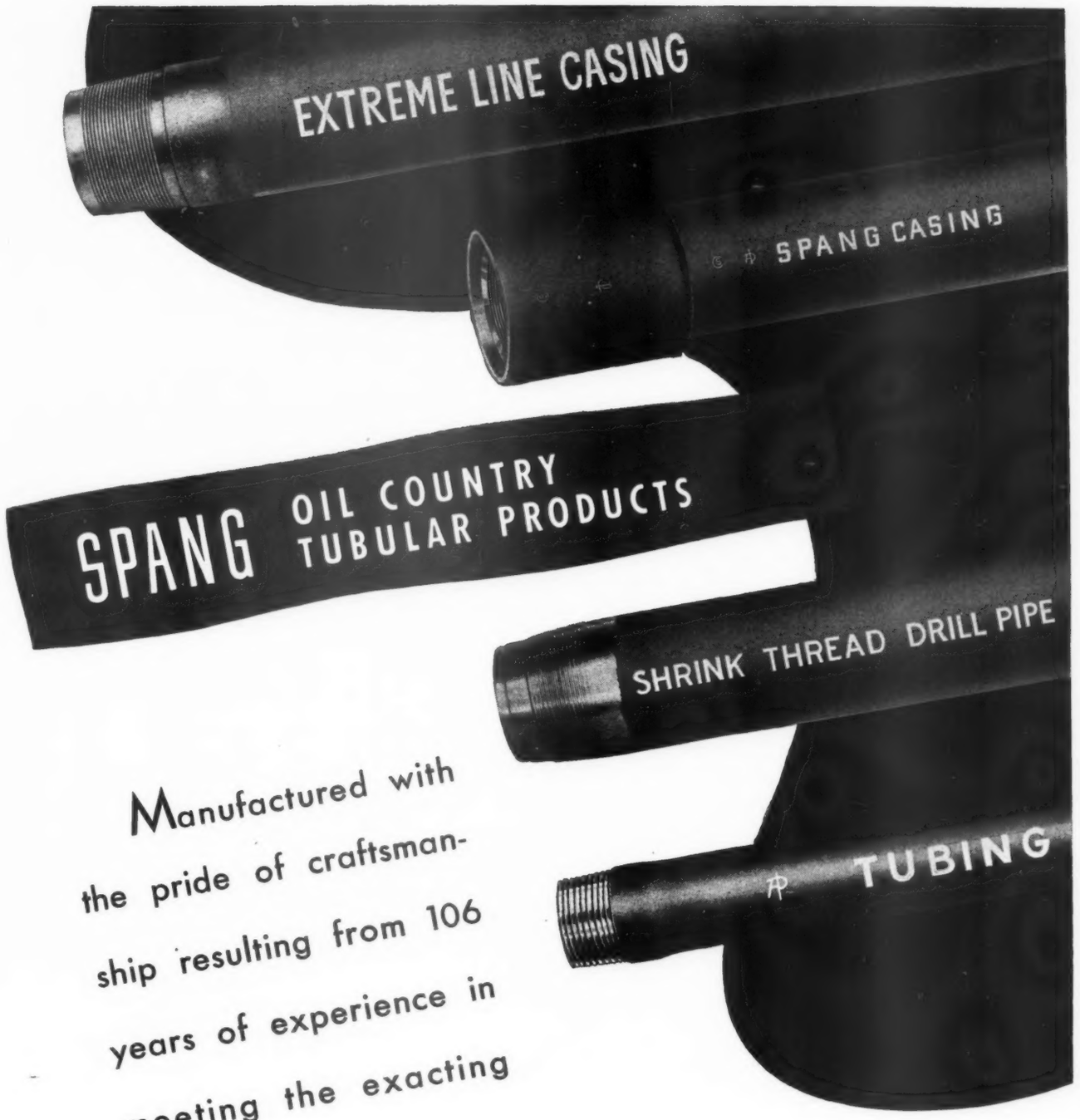
It would seem as though a study of methods that have yielded 28 billion bbl. of oil to date from fields in the United States would supply enough evidence to arrive at a satsfactory conclusion, and yet there seems to be much uncertainty of the best methods to employ. Three years ago the writer prepared tables of groups of many of the principal fields of the United States showing the per-acre recovery, and in some areas where different methods had been employed it appeared that greater per-acre recovery was made from those fields in which spacing was close, and where the production had been close to the maximum capacity[1, 2, 3]. The writer recognized weakness in the evidence in that the thickness of the producing formation was not taken into account, and justifiable criticism was directed toward these comparisons on this score. The tables in this article are intended to introduce thicknesses as a factor so far as published data are obtainable, in order to avoid like criticism. It should be remembered, however, that porosity is an important factor, without the use of which close accuracy in comparisons of recovery is not possible. It is impossible, however, to obtain figures on porosity that have much meaning, especially when applied to the older fields. In fact, average porosities determined for newly opened fields are far from satisfactory. Porosities of a particular section of a core are often determined, but seldom is the average porosity of an entire thickness ascertained, and even this in a 7-in. hole applies to only 1 part in 6.5 million of an area where spacing is on basis of 40 acres per well. Consequently, the introduction of porosities into calculations of this nature still leaves much doubt as to the value of such comparisons.

The total volume of an acre-foot is 7758 bbl., and as a porosity of 25 per cent is fairly high, it is obvious that with 25 per cent porosity a total recovery of 1940 bbl. of oil per acre-foot is all that can be hoped for, even if the total contents are oil, and if the recovery is 100 per cent. Consequently, any recovery that is greater than 2000 bbl. per acre-foot must be scrutinized very carefully. Such high acre-foot recoveries usually imply error in acreage, or thickness, or indicate drainage from surrounding productive territory. When treating a field as a whole, however, drainage need not be considered unless there is error in the area considered as productive.

The figures given in the tables presented in this article are mostly as of January 1, 1944, and are obtained from Vol. 155, *A.I.M.E. Petroleum Development and Technology*, with the exception of figures for estimated ultimate recovery, which are taken from the *Oil and Gas Journal* of January 27, 1944, except where otherwise noted. It has been the intention to confine the use of these figures to those obtained from published data that are available to all.

In Table 1, there are given data on the 51 fields in the United States in each of which the production has reached approximately 100 million bbl. Cumulative production of these 51 fields has amounted to 13 billion bbl. from 762,000 acres, which is almost 50 per cent of the total production of the United States to 1944. Estimated ultimate recovery as of January 1, 1944, for these fields was 20.4 billion bbl. or about 40 per cent of the total estimated recovery for the United States from fields already developed. Figures for thicknesses are stated for 35 of these fields for which the area is 498,000 acres averaging 103.9 ft. in thickness, from which cumulative production has amounted to 9,483 billion bbl., or 19,200 bbl. per acre, or 185 bbl. per acre-foot. Ultimate recovery of these fields is

1. "Review of Ultimate Recovery Factors and Methods of Estimating," S. F. Shaw. *Oil Weekly*, July 13, 1942, p. 16.
2. "Influence on Ultimate Recovery of Methods of Extraction," S. F. Shaw. *Oil Weekly*, November 2, 1942, p. 28.
3. "Recoveries Obtained Under Different Extraction Methods in Various Fields," S. F. Shaw. *Oil Weekly*, December 7, 1942, p. 25, and December 14, 1942, p. 22.



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estimated at 16,059 billion bbl., or 32,000 bbl. per acre, or 311 bbl. per acre-foot.

An additional list of 18 fields is given in Table 1-A in which the reserves of each field are estimated at 100 million bbl. or more, which combined with the fields in Table 1, raises the total cumulative recovery to 13.9 billion bbl., or nearly 50 per cent of the cumulative production of the United States, and estimated ultimate recovery of these 69 fields reaches a total of 25.5 billion bbl., or a little over 50 per cent of the total estimated ultimate recovery from presently developed fields of the United States. The importance of these 69 fields to the oil industry is, therefore, evident.

Cumulative recovery from the 18 fields listed in Table 1-A to January 1, 1944, amounted to 1930 bbl. per acre, or 32 bbl. per acre-foot, and the ultimate recovery of these same fields is estimated at 11,950 bbl. per acre, or 200 bbl. per acre-foot.

From Table 1 are taken 10 of the older fields and listed in Table 2, which are now almost 90 per cent depleted, for which thicknesses are stated. The area aggregates 134,910 acres, having average thickness of 63.5 ft., and aggregate production of 1560 million bbl., or 11,570 bbl. per acre, or 182 bbl. per acre-foot. The ultimate recovery is estimated at 1776 million bbl. or 13,170 bbl. per acre, or 208 bbl. per acre-foot. Either productive area or thickness of these fields may be incorrect, but the figures are according to the present record. The figures per acre-foot are considerably lower than those employed for estimating the recovery from such fields as East Texas, Anahuac, West Ranch, Penn-Jordan, and many others in which estimates are necessarily computed by means of the volumetric method.

● **Data on old fields in Arkansas.** In Table 3 is given a list of 5 of the old fields of Arkansas for which thicknesses are stated. The area aggregates 39,120 acres, averaging 30.7 ft. in thickness, from which 480.4 million bbl. have been extracted, which is an average of 12,280 bbl. per acre, or 400 bbl. per acre-foot.

TABLE 2-A

Data on fields having principal future reserves. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	East Texas	1930	Woodbine	136,000	35	1,960,000	14,560	416	4,500,000	33,100	940
2	Midway-Sunset	1901	Etch, Maricopa, Plio, Mio	33,000	65	660,321	20,000	308	1,160,000	35,100	543
3	Coalinga	1900	Etch, Temblor	22,025	199	436,585	19,800	99	850,000	38,500	193
4	Long Beach	1921	Pico, Repetto, Puente	1,600	1650	688,194	432,300	260	790,000	493,000	290
5	Conroe	1931	Cockfield	17,660	30	161,943	9,180	306	700,000	39,600	1320
6	Yates	1926	San Andres	20,000	100	275,188	13,780	138	671,700	33,580	336
7	Kettleman Hills	1928	Temblor, Avenal, Mio, Eoc	16,720	850	280,596	16,700	20	430,500	25,600	30
8	Slaughter	1936	San Andres	65,000	32	25,779	400	13	471,320	7,240	220
9	Wasson	1936	San Andres, Clear Fork	55,000	50	54,948	990	20	453,550	8,250	164
10	Van	1929	Nacatoch, Woodbine	4,520	129	139,460	30,900	239	440,010	97,500	756
11	Huntington Beach	1920	Repetto, Puente	2,200	1200	326,208	148,300	124	440,000	200,000	167
12	Tom O'Connor	1934	Frio	12,000	175	46,684	3,890	22	400,000	33,300	190
13	Wilmington	1935	Repetto, Puente, Plio, Mio	4,400	420	207,829	47,230	113	500,000	113,500	270
14	Ventura Ave.	1916	Pico, Repetto, Plio	2,060	3000	267,890	130,000	43	435,000	211,000	70
15	Eunice-Monument	1928	Grayburg, San Andres	40,320	82	124,055	3,070	37	371,000	9,200	112
16	Goldsmith-Harper	1933	San Andres	28,000	58.6	55,059	19,660	336	383,710	13,650	233
17	Hastings	1934	Frio	5,800	200	63,545	10,900	55	370,000	63,800	319
18	Webster	1937	Frio	4,000	150	24,077	6,020	40	350,000	87,500	583
19	Elk Hills	1919	San Joaquin, Etch.-Stevens, Plio, Mio	10,000	75	167,474	16,740	223	385,000	38,500	513
20	Anahuac	1935	Frio	7,000	60	32,570	4,650	78	290,000	41,400	690
21	K.M.A.	1931	Strawn, Ellenburger	36,000	25.8	57,623	1,600	62	280,000	7,800	301
22	West Ranch	1938	Het, Marg, Frio	10,000	24	17,882	1,800	75	238,000	23,800	995
23	McElroy	1926	Grayburg	14,000	40	133,179	9,510	238	226,000	16,150	404
24	Thompson	1931	Miocene, Frio, Vicksburg	6,515	95	48,706	7,480	79	225,000	34,500	365
25	Cowden-Foster	1930	Grayburg	40,930	41.2	49,727	1,215	30	214,500	5,730	139
26	Hawkins	1940	Sub-Clarksville, Woodbine	8,500	160	21,138	2,520	16	200,000	23,500	147
27	Louden	1937	Cypress, Paint Creek, Bethel, Devonian	20,650	37.1	101,336	4,900	132	195,500	9,470	255
28	Magnolia	1938	Cotton Valley, Reynolds	4,414	100	30,716	6,950	70	150,000	34,000	340
29	Penwell-Jordan	1930	San Andres	11,820	25.2	31,607	2,680	106	166,510	74,100	560
30	South Ward	1928	Seven Rivers	17,700	43	49,764	2,700	63	145,070	8,190	190
31	Seminole, Texas	1937	San Andres	12,500	90	8,197	660	7	110,000	8,800	96
32	Cut Bank	1932	Cut Bank, Kootenai	38,000	30	36,858	940	31	116,000	3,050	102
			Total	708,334	97.2	6,630,379	9,300	96	16,658,370	23,520	242

TABLE 3

Data on production of older fields in Arkansas. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Champagnolle	1927	Tokio, Hosston	2,030	15	15,429	7,600	507	18,000	8,870	590
2	El Dorado	1920	Nacatoch	7,980	20	49,047	6,150	307	52,600	6,600	330
3	Irma-Troy	1921-1936	Nacatoch, Tokio	1,400	21	10,151	7,250	345	14,400	10,300	490
4	Rodessa	1931	Rodessa lime	1,950	25	6,821	3,500	144	8,000	4,110	164
5	Smackover	1922	Nacatoch, Graves, Tokio	25,760	36.2	398,933	15,420	426	435,000	16,900	468
			Total	39,120	30.7	480,380	12,280	400	528,000	13,500	440
			Total for State, 41 fields	76,025		607,299	7,970		970,252	12,750	

TABLE 4

Data on production of old fields in California. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Long Beach	1921	Pico, Repetto, Puente	1,600	1650	688,194	430,000	262	790,000	493,800	299
2	Midway-Sunset	1901	Etchegoin, Maricopa	33,000	65	660,321	20,000	308	801,000	24,300	374
3	Santa Fe Springs	1919	Repetto, Puente	1,630	1360	492,234	302,000	222	550,000	337,400	248
4	Huntington Beach	1920	Repetto, Puente	2,200	1200	326,208	148,000	124	440,000	200,000	167
5	Kern River	1899	Kern River	6,700	130	283,449	42,300	325	310,000	46,300	356
6	Brea Olinda	1889	Repetto, Puente	1,680	800	175,846	104,700	131	200,000	119,000	149
7	Montebello	1917	Repetto, Puente	1,750	800	135,138	77,000	96	160,000	91,500	114
8	Torrance	1922	Puente	6,200	120	110,049	17,800	148	135,000	21,800	182
9	Richfield	1919	Puente	1,370	510	97,331	71,000	139	126,000	92,000	180
			Total	56,130	280.8	2,968,770	52,890	206	3,512,000	62,600	241
			Total for State, 98 fields	219,855	280.8	6,374,003	29,900	103	9,354,085	42,500	151

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TABLE 5

Data on production of old fields in Illinois. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Aden	1938	Aux Vases, McClosky, Levias, Rosiclare	880	37	821	1,900	51	5,500	2,700	73
2	Aden, North	1938	Aux Vases, McClosky	1,160	27.6	3,063		51		2,700	73
3	Benton	1941	Tar Springs	2,020	34	14,710	7,280	214	23,700	1,170	34
4	Centralia	1937	Cypress, Bethel, Devonian, Trenton	2,850	89	36,920	12,900	145	47,200	16,600	186
5	Cisne	1937	Aux Vases, Rosiclare, McClosky	920	32	2,972	3,230	101	4,100	4,460	140
6	Clay City	1937	Cypress, Bethel, Aux Vases, Rosiclare, McClosky	14,380	44	30,454	2,120	50	44,300	3,090	70
7	Colmar-Plymouth	1914	Hoing, Devonian	2,450	21	2,991	1,220	58	4,000	1,630	78
8	Iron	1940	Tar Springs, Hardinsburg, Cypress, Bethel, McClosky	770	66	2,701	3,510	53	3,800	4,930	74
9	Omaha	1940	Palestine, Tar Springs, McClosky	260	30	809	3,100	103	1,300	5,000	167
10	St. James	1938	Cypress	1,900	16	6,783	3,570	223	10,600	5,580	349
11	Salem	1938	Bethel, Aux Vases, Rosiclare, McClosky, Salem, Devonian, Trenton	9,270	217	177,241	19,100	88	214,200	23,100	107
12	Sandoval	1919	Benoist, Devonian	770	24.4	5,038	6,540	268	5,600	7,270	298
13	Storms	1939	Waltersburg, Cypress, Palm Creek	1,510	42	4,136	2,740	65	5,300	3,510	84
			Total	39,140	83.9	288,639	7,370	88	369,600	9,440	113
			Total for State, ±200 fields	258,575		1,021,880	3,940		1,424,817	5,500	

TABLE 6

Data on production of old fields in Kansas. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Augusta	1914-1916	Lansing, Bronson, Marmaton, Wilcox	10,280	58.1	48,067	4,680	80	51,400	5,000	86
2	Burrton	1931	Chat, Hunton	5,000	48	36,913	7,380	154	45,800	9,160	191
3	Churchill	1926	Stalnaker	1,000	25	18,733	18,730	749	20,700	20,700	828
4	Eastborough	1929	Chat, Viola	1,000	18	8,339	8,340	463	9,300	9,300	516
5	Fairport	1923	Lansing, Gorham	3,600	17	16,265	4,520	266	21,400	5,950	350
6	Graber-Hesston	1934	Misener, Hunton	2,800	27	7,545	2,700	100	11,500	4,110	152
7	Greenwich	1929	Chat, Viola, Simpson	700	12	9,715	1,390	116	11,300	1,610	134
8	Halstead	1929	Chat	1,200	30	1,464	1,220	41	2,100	1,750	58
9	Hollow-Nickel	1931	Chat, Hunton, Simpson	1,500	32	19,434	12,900	403	21,600	14,400	450
10	Johnson	1932	Chat	1,200	14	2,807	2,340	167	3,600	3,000	214
11	Lorraine	1934	Lansing, Arbuckle	5,500	45	9,136	1,670	37	12,400	2,250	50
12	Oxford	1927	Stalnaker, Layton, Arbuckle	800	41	14,867	18,580	453	17,000	21,300	520
13	Rainbow-Genda	1923-1936	Burgess, Bartlesville, Chat	2,600	49.1	14,430	5,540	113	16,600	6,380	130
14	Ritz-Canton	1929	Lansing, Chat, Viola, Simpson	13,000	76	31,011	2,850	38	44,200	3,400	45
15	Robbins	1929	Mississippi lime	420	12	3,114	7,410	618	4,800	11,430	950
16	Sallyards	1921	Bartlesville	8,000	40	28,513	3,560	89	30,900	3,860	97
17	Valley Center	1928	Misener, Viola	1,500	9	20,820	13,880	1542	23,300	15,530	1726
18	Virgil-Dunaway	1916	Mississippi, Bartlesville	14,000	76.9	33,196	2,370	31	38,400	2,740	36
19	Voshell	1929	Chat, Viola, Simpson, Arbuckle	3,500	31	24,704	7,060	228	29,500	8,430	271
20	Welch	1934-1937-1941	Chat	1,740	41.1	4,508	2,590	63	5,200	2,980	73
21	Wellington	1929	Chat	1,200	11	5,264	4,390	40	6,900	5,750	52
22	Wherry	1933	Sooy	7,200	22	8,947	1,240	56	11,700	1,630	47
			Total	87,740	48.9	373,792	4,260	87	439,600	5,000	102
			Total for state, 321 fields	496,290		1,248,790	2,520		2,153,934	4,330	

Ultimate recovery is estimated at 528 million bbl., or 13,500 bbl. per acre, or 400 bbl. per acre-foot. Most of the production of this group comes from sand formations, and the average acre-foot is considerably higher than for groups in which considerable producing limestone formations are found. The total productive area for the state to January 1, 1944, consists of 76,025 acres from which there had been a cumulative production of 607.3 million bbl., or 7970 bbl. per acre; the ultimate recovery is estimated at 970.3 million bbl., or 12,750 bbl. per acre. Recoveries per acre-foot cannot be computed because thicknesses are not given for many of these fields.

● **Data on production from older fields of California.** Table 4 contains a list of 9 older fields in California for which thicknesses are stated. The combined area of this group is 56,130 acres with a 280.8-ft. average thickness, having a cumulative production of 2969 million bbl., or 52,890 bbl. per acre, or 206 bbl. per acre-foot. Estimated ultimate recovery aggregates 3512 million bbl., or 62,600 bbl. per acre, or 241 bbl. per acre-foot. The average acre-foot recovery for these California fields is higher than generally supposed in comparison with the average of large fields east of California. The estimated ultimate recovery per acre-foot of the various California fields does not vary as widely as for Eastern areas.

Total production from all California fields has amounted to 6374 million bbl. from 219,855 acres, or 29,000 bbl. per acre. Total ultimate recovery for the state is estimated at 9354 million bbl., or 42,500 bbl. per acre. Thicknesses are not stated for all these fields, therefore acre-foot recoveries cannot be computed. If, however, the average of 280.8 ft. that applies to the fields in Table 4 be tentatively used, the ultimate recovery for the entire state would be 150 bbl. per acre-foot.

● **Data on production of old fields in Illinois.** Little data are available on the earliest-developed fields of Illinois that would permit acre-foot recoveries to be computed. Table 5 presents a list of 12 fields in which cumulative production amounts to almost 80 per cent of the estimated ultimate recovery.

The total area of these 12 fields amounts to 39,140 acres, averaging 83.9 ft. in thickness from which cumulative production to January 1, 1944, amounts to 288.6 million bbl., or 7370 bbl. per acre, or 88 bbl. per acre-foot. The ultimate recovery is estimated at 369.6 million bbl., or 9440 bbl. per acre, or 113 bbl. per acre-foot. The Salem field has produced 177.2 million bbl. of the 288.6 million bbl. of cumulative production of these 12 fields, therefore, has a large influence on the average acre-foot recovery, nevertheless, the average cumulative acre-foot production for Salem is the same as that for the combined fields shown in Table 5. This average of 113 bbl. per acre-foot recovery is low, but low acre-foot recoveries are typical of most limestone formations.

The total cumulative production for Illinois from 258,575 acres is 1022 million bbl. or 3940 bbl. per acre. Estimated total ultimate recovery for the state is 1424.8 million bbl., or 5500 bbl. per acre.

Thicknesses of producing formations in nearly all cases are stated, whenever there is more than one sand in the same field, but the area of each horizon is not specified, therefore, the thickness summed up arithmetically is probably far from correct. Nevertheless, such figures are the only ones that can be used as obtained from published data. The thickness of the different formations could be stated, as is the case for the

TABLE 7

Data on old fields in North Louisiana. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Bellevue	1921	Nacatoch, Rodessa	1,360	30	10,795	7,930	264	12,400	9,120	304
2	Caddo	1905	Nacatoch, Paluxy, Saratoga, Ferry Lake, Tokio, Rodessa, Sligo	60,000	65	157,829	2,630	41	182,500	3,040	47
3	Carterville-Sarepta	1922	Tokio	4,250	30	2,856	672	22	4,300	1,010	34
4	Converse	1932	Saratoga, Paluxy	5,760	20+	2,508	435	20	3,500	6,080	304
5	Elm Grove	1916	Nacatoch, Paluxy, Ozan, Tokio	14,920	102	3,633	244	2	4,700	315	3
6	Homer	1919	Nacatoch, Cotton Valley, Tokio,	3,020	174	72,998	24,200	139	83,000	27,500	160
7	Lisbon	1936	Sligo, Hosston, Cotton Valley, Smackover	8,320	147	10,575	1,270	9	16,600	1,990	133
8	Red River	1912	Nacatoch, Saratoga, Paluxy	37,000	40	57,406	1,550	39	61,300	1,660	42
9	Rodessa	1930	Rodessa	10,000	125	79,295	7,930	63	98,700	9,870	79
10	Urania-Tullos	1925	Wilcox	6,600	9	26,618	4,030	447	34,000	5,150	572
			Total	151,230	67.7	424,613	2,810	42	501,000	3,310	49
			Total North Louisiana, 70 fields	206,880		604,249	2,910		865,490	4,170	

TABLE 8

Data on production of old fields in South Louisiana developed before 1930. As of January 1, 1943.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Jennings	1901	Mio U	800	101	84,108	105,000	1040	135,000	168,500	1688
2	Hackberry E-W	1927	Mio U, Mio L	1,440	82.6	43,432	30,200	366	70,000	48,700	847
3	Vinton	1910	Mio U, Mio L	360	15	44,185	122,700	8180	49,000	136,000	9080
4	Iberia	1917	Plio, Mio U	300	135	29,586	98,620	730	45,000	150,000	1110
5	Sulphur	1926	Mio U, Mio L	200	50	17,466	87,330	1747	24,100	120,500	2410
6	Lockport	1924	Plio, Mio U, Mio L	640	20	15,277	23,900	1195	18,500	28,900	1445
7	Lake Barre	1929	Mio U	500	50	17,829	35,660	713	19,000	38,000	760
8	Port Barre	1929	Mio U, Mio L, Olig, Claiborne	500	73	12,032	24,060	329	20,000	40,000	548
9	Black Bayou	1929	Mio U, Mio L	300	80	10,740	35,800	447	18,000	60,000	750
10	Sweet Lake	1926	Mio U	200	30	6,781	33,900	1130	7,000	35,000	1167
11	Edgerly	1912	Mio U	215	18	8,565	39,800	2220	10,400	48,400	2694
			Total	5,455	66.7	290 001	53,160	800	416,000	76,300	1144
			Total south Louisiana, 138 fields	68,675		813,902	11,800		1,626,073	23,600	

TABLE 9

Data on nearly depleted fields in South Louisiana developed since 1930. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.*	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Bancroft	1938	Cockfield	750	12	3,325	4,400	367	5,000	6,670	556
2	Bosco	1934	Mio L	2,240	27	24,429	10,900	404	31,000	13,800	511
3	Caillou Island	1930	Mio U	540	67	35,553	65,800	982	50,000	92,600	1383
4	Bayou Choctaw	1931	Mio U	120	50	4,008	33,400	668	5,500	45,830	917
5	Darrow	1932	Mio U, Mio L	175	72	5,937	33,800	470	8,500	48,600	675
6	Gillis	1934	Mio U, Mio L	1,200	12	22,542	18,790	1566	27,100	22,600	1883
7	Iowa	1931	Mio U, Mio L	1,040	148	51,675	49,700	336	74,600	71,700	484
8	Roanoke	1934	Mio L	1,080	56	10,356	9,600	1714	15,000	13,900	2482
9	Tepetate	1935	Mio L	1,000	60	12,326	12,326	205	22,000	22,000	367
10	Valentine	1936	Mio L	220	50	5,562	25,300	506	6,400	29,100	582
			Total	8,365	50.7	175,713	21,000	414	245,100	29,300	578

*Thickness as of January 1, 1943.

Louden field, which would give a much better understanding of the average thickness. Average thicknesses are carried out to one decimal place to indicate that a weighted average has been computed where there is more than one producing formation.

● **Data on old fields in Kansas.** Table 6 lists 22 fields in Kansas in which thicknesses are stated, for which the ultimate recovery is estimated at less than 12 per cent greater than the cumulative recovery. The productive area of these 22 fields is 87,740 acres, having an average thickness of 48.9 ft. Cumulative recovery had reached 373.8 million bbl. by January 1, 1944, or 4260 bbl. per acre, or 87 bbl. per acre-foot. Ultimate recovery is estimated at 439.6 million bbl., or 5000 bbl. per acre, or 102 bbl. per acre-foot. The ultimate recovery ranges from 36 to 1726 bbl. per acre-foot. This estimated recovery of 1726 bbl. per acre-foot at Valley Center appears very high, and it may be that the thickness of 9 ft. is too low. Even 828 bbl. per acre-foot for the Churchill pool appears high for the Stalnaker sand.

Total cumulative recovery from Kansas fields has been 1248.8 million bbl. from 496,000 acres, or 2500 bbl. per acre. Ultimate recovery is estimated at 2153.9 million bbl, or 4300 bbl. per acre.

● **Data on production from old fields in North Louisiana.** Ten older oil fields in North Louisiana with aggregate productive area of 151,230 acres are listed in Table 7. The average thickness is 67.7 ft., and cumulative production has been 424.6 million bbl., or 2810 bbl. per acre, or 42 bbl. per acre-foot. The ultimate recovery from these combined 10 fields is estimated at 501 million bbl., or 3310 bbl. per acre, or 49 bbl. per acre-foot. Cumulative production is about 85 per cent of the total estimated ultimate recovery.

Bellevue and Urania have yielded the highest acre-foot recoveries at 264 and 447 bbl., respectively. Both of these fields have produced large quantities of water, and Urania in 1944 still averaged 2000 bbl. a day, with very high percentage of water.

Acre-foot recovery, as averaged in Table 7, is disproportionately influenced by the very low recoveries from Caddo, Elm Grove, and Red River fields, which are so low as to lead one to suspect that either productive areas or thicknesses are too high.

The total productive area in North Louisiana is 206,880 acres, from which 604.2 million bbl. have been produced, or 2910 bbl. per acre, and ultimate recovery from this area is estimated at 865.5 million bbl., or 4170 bbl. per acre. The figure for acreage may be incorrect, due to possible addition of acreage for gas, which is not denoted as such in the source of the information from which the figures in the table are taken.

● **Data on production from old fields in South Louisiana.** Notable acre-foot

TABLE 10

Data on South Louisiana fields developed after 1930. Revised thicknesses as of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft
1	Bancroft	1938	Cockfield	750	15	3,325	4,400	298	5,000	6,670	445
2	Bosco	1934	Mio L	2,240	180	24,429	10,900	605	31,000	13,800	767
3	Caillou Island	1930	Mio U	540	1020	35,553	65,800	65	50,000	92,600	91
4	Choctaw Bayou	1931	Mio U	120	80+	4,008	33,400	417	5,500	45,830	573
5	Darrow	1932	Mio U, Mio L	175	295	5,937	33,800	115	8,500	48,600	165
6	Gillis	1934	Mio U, Mio L	1,200	210	22,542	18,790	90	27,100	22,600	189
7	Iowa	1931	Mio U, Mio L	1,040	750	51,675	49,700	66	74,600	71,700	96
8	Roanoke	1934	Mio L	1,080	360	10,356	9,600	27	15,000	13,900	39
9	Tepetate	1935	Mio L	1,000	120	12,326	12,326	1027	22,000	22,000	183
10	Valentine	1936	Mio U	220	350	5,562	25,300	72	6,400	29,100	83
			Total	8,365	316	175,713	21,000	66	245,100	29,300	93

TABLE 11

Data on production of old fields in Michigan. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Beaverton	1935	Dundee	880	12	1,128	1,280	107	1,900	2,160	180
2	Bentley	1937	Dundee	920	25	820	890	36	1,300	1,410	56
3	Bloomingdale	1938	Traverse	3,000	4	5,868	1,960	490	....	....	....
4	Buckeye	1936	Dundee	5,400	11	18,980	3,500	318	22,400	4,150	377
5	Clayton	1936	Dundee	1,300	12	3,832	2,950	246	5,300	4,080	340
6	Crystal	1935	Dundee	2,180	4	7,260	3,330	832	....	....	....
7	Muskegon	1927	Traverse, Dundee	2,700	13.5	6,740	2,500	185	....	....	....
8	Porter-Yost	1931	Dundee	8,440	12	40,435	4,800	400	46,000	5,500	458
9	Saginaw	1925	Berea	1,800	16	1,414	730	46	....	....	....
10	Sherman	1936	Dundee	1,220	4	4,186	3,430	857	4,500	3,690	922
11	Vernon-Leaton	1930-1929	Dundee	3,240	6.0	7,569	2,330	388	8,100	2,500	417
12	Walker	1938	Traverse	5,700	6	9,461	1,660	277	10,800	1,890	315
13	West Branch	1933	Traverse, Dundee	5,000	25	5,188	1,040	42	6,600	1,320	53
14	Wise	1938	Dundee	1,320	10.5	1,906	1,440	138	2,600	1,970	188
			Total 14 fields	43,100	11.4	114,737	2,660	234	....	....	....
			Total 10 fields	33,420	12.2	....	....	....	109,500	3,280	269
			Total for State, 79 fields	153,100		203,902	1,330		298,670	1,950	

recoveries have been obtained in the old South Louisiana oil fields. The aggregate area of 11 fields listed in Table 8 for which thicknesses are stated, amounts to 5455 acres, averaging 66.7 ft. in thickness. The cumulative production has amounted to 290 million bbl., or 53,160 bbl. per acre, or 800 bbl. per acre-foot. Total ultimate recovery is estimated at 416 million bbl., or 76,300 bbl. per acre, or 1144 bbl. per acre-foot.

Cumulative recovery of 8180 bbl. per acre-foot at Vinton is incorrect, of course, but data are not available that would locate the discrepancy. With a porosity considerably in excess of 25 per cent, production of 2220 bbl. oil per acre-foot at Edgerly is possible, but not probable.

A total of 138 fields is listed in South Louisiana, having combined area of 68,675 acres. The acreage of oil producing lands is uncertain, however, owing to possible inclusion of gas acreage that may be a duplication. The production of oil has amounted to 813.9 million bbl. or 11,800 bbl. per acre. Total ultimate recovery is estimated at 1626.1 million bbl., or 23,600 bbl. per acre. The 11 fields listed in Table 8, with 9 per cent of the total productive area in South Louisiana, are estimated to yield 30 per cent of the total ultimate recovery from the fields in this area so far developed.

The fields enumerated in Table 8 were developed before 1930 with close spacing, and production was as close to maximum capacity as possible to obtain. These figures afford an interesting comparison with the fields listed in Table 9.

● **Data on fields in South Louisiana developed since 1930.** In Table 9 is presented a list of fields in south Louisiana that have been discovered since 1930, which have been depleted about 70 per cent. These fields cover an area of 8365 acres, averaging 50.7 ft. in thickness, according to thicknesses stated as of January 1, 1943. The cumulative recovery was 175.7 million bbl. as of January 1, 1944, averaging 21,000 bbl. per acre, or 414 bbl. per acre-foot. Aggregate ultimate recovery is estimated at 245.1 million bbl., or 29,300 bbl. per acre, or 578 bbl. per acre-foot, which per acre-foot recovery is about one-half that estimated for the fields listed in Table 8. These fields in Table 9 have been developed with wider spacing, and have been considerably restricted from their maximum daily capacity.

Ultimate recoveries of 2482 bbl. at Roanoke and 1883 bbl. per acre-foot at Gillis seem high, and this may be due to thicknesses assumed at too low a figure. A surprising figure is that of 367 bbl. per acre-foot at Tepetate as the ultimate recovery, which is the lowest acre-foot recovery estimated in this list. This suggests a scrutiny of the thickness assumed for the sand at Tepetate.

Extensive revisions of thicknesses were made of the fields of south Louisiana as of January 1, 1944, the results of which are given in Table 10, from which it would appear that cumulative recovery was reduced from 414 bbl. per acre-foot in Table 9 to 66 bbl. per acre-foot in Table 10. Also ultimate recovery estimated at 578 bbl. per acre-foot in Table 9 becomes reduced to 93 bbl. per acre-foot. This revision brings out the importance of determining the productive thicknesses as accurately as possible, if reliable estimates are to be hoped for.

● **Data on old fields in Michigan.** Most of the fields in Michigan listed in Table 11 are producing from the Dundee formation; 4 of the fields have production in the Traverse. The 14 fields with thicknesses stated cover an area of 43,100 acres, averaging 11.4 ft. in thickness for which the cumulative production to January 1, 1944, was 114.7 million bbl. or 2660 bbl. per acre, or 234 bbl. per acre-foot. Ultimate recovery from 10 of these fields for which estimates of ultimate recovery are available amount to 109.5 million bbl. from 33,420 acres averaging 12.2 ft. in thickness, which is an average of 3280 bbl. per acre, or 269 bbl. per acre-foot. Average thickness of 11.4 ft. in Michigan compares with 83.9 ft. in Illinois, but ultimate recoveries in Michigan are estimated at 269 bbl. per acre-foot compared with 113 bbl. per acre-foot in Illinois. Possibly methods of measuring thickness has something to do with these differences.

Total productive area of 79 fields in Michigan amounts to 153,100 acres from which cumulative production has been 203.9 million bbl. or 1330 bbl. per acre. Total ultimate recovery of these 79 fields is estimated at 298.7 million bbl., or 1950 bbl. per acre.

Editor's note: The second installment of this two-part article by S. F. Shaw will appear in an early issue.

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TURNAROUNDS IN FLUID CATALYTIC CRACKING UNITS

By L. R. HILL*
and
J. W. MOORMAN**

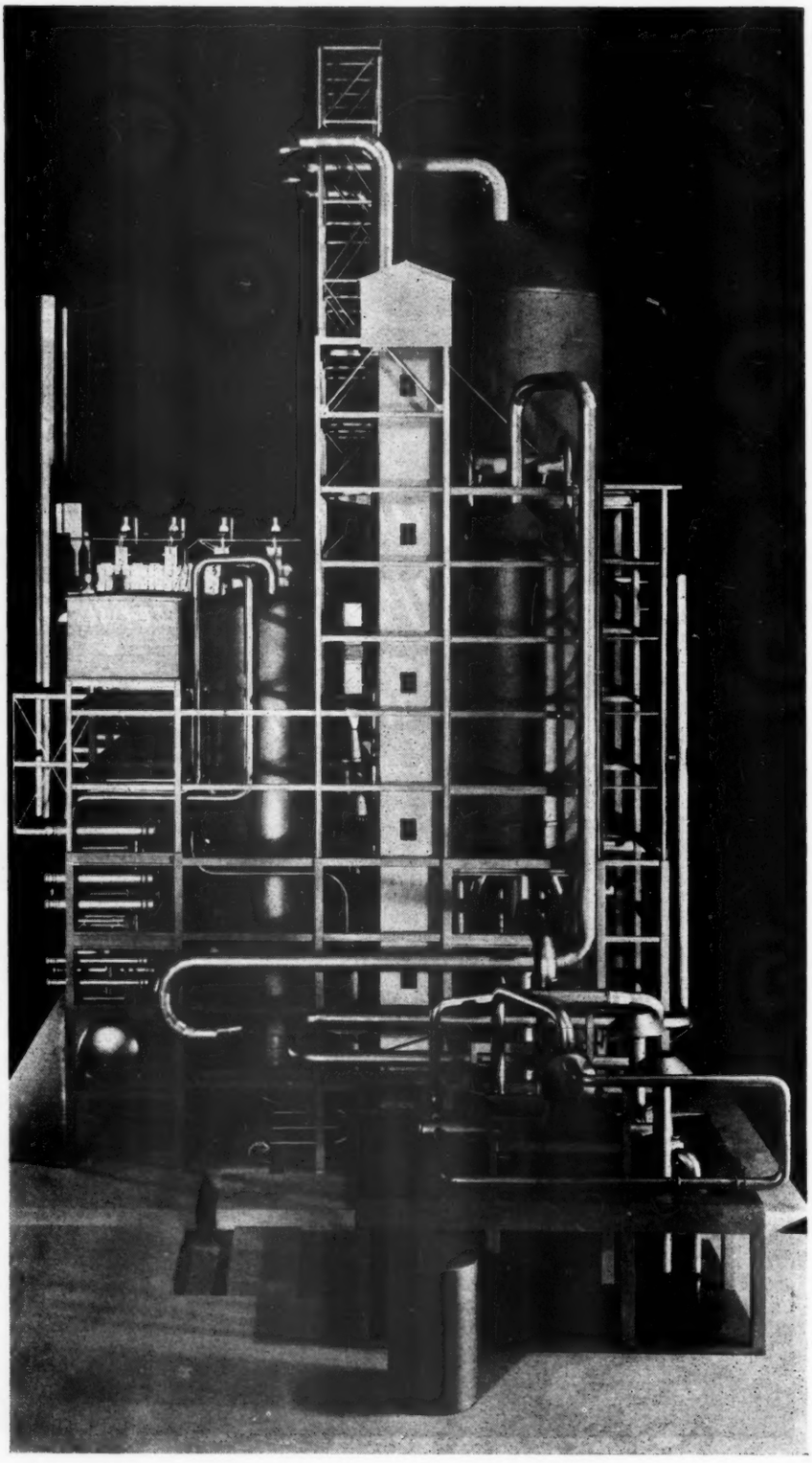
EXCLUSIVE

THERE was a time in the oil industry when refining equipment was kept on stream until it ceased to function efficiently or broke down completely. With the advent of modern processing, however, resulting in products of superior quality, the value of refining equipment entailed too great an investment, and down time too great a loss, for any such hit or miss method of maintenance scheduling. Therefore, within the past decade, oil companies have adopted the practice of *pre-scheduling* their various equipment for "turnarounds" or inspection shutdowns. The length of individual runs has varied, but many were planned for 6-month durations. For example, fluid catalytic cracking units were scheduled for 6-month runs when they were first put into operation. Experience, however, has proved that, for FCC units, there is no necessity for such short runs. The condition of equipment found during turnarounds indicates that their continuous on-steam time can be, and in fact has been, progressively increased to a length of well over a year.

In the early days of fluid catalytic cracking unit operation (1942-44), extremely careful and complete inspections were made at the completion of each run, and valuable data were compiled from such periodic inspections. This large volume of information has provided a comprehensive outline of the effects of erosion, corrosion, and mechanical wear on these units. Although the information summarized in the following paragraphs reflects only the results of the operations and inspections of Kellogg designed and built units, it is felt that it provides a fair indication of the current status in the whole fluid cracking industry.

The purpose in following the operations of a large number of FCC units was threefold. First, to cooperate with the oil companies concerned in providing essential information for efficient operation of their units in order that maximum production of aviation gasoline be achieved. Second, to obtain addi-

*Director, Process Engineering Dept., The M. W. Kellogg Company.
**Process Engineer, The M. W. Kellogg Company.



Pilot plant model, an accurate replica in both detail and scale, has been found useful in planning construction changes, turning turnarounds, facilitating discussions on fluid units, teaching drafting students, design changes, etc.

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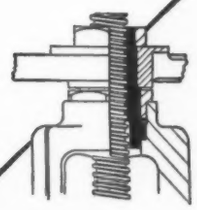

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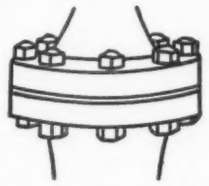

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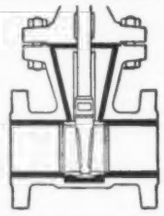

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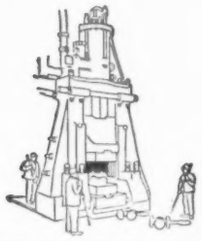

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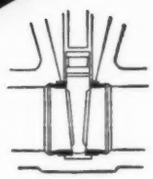

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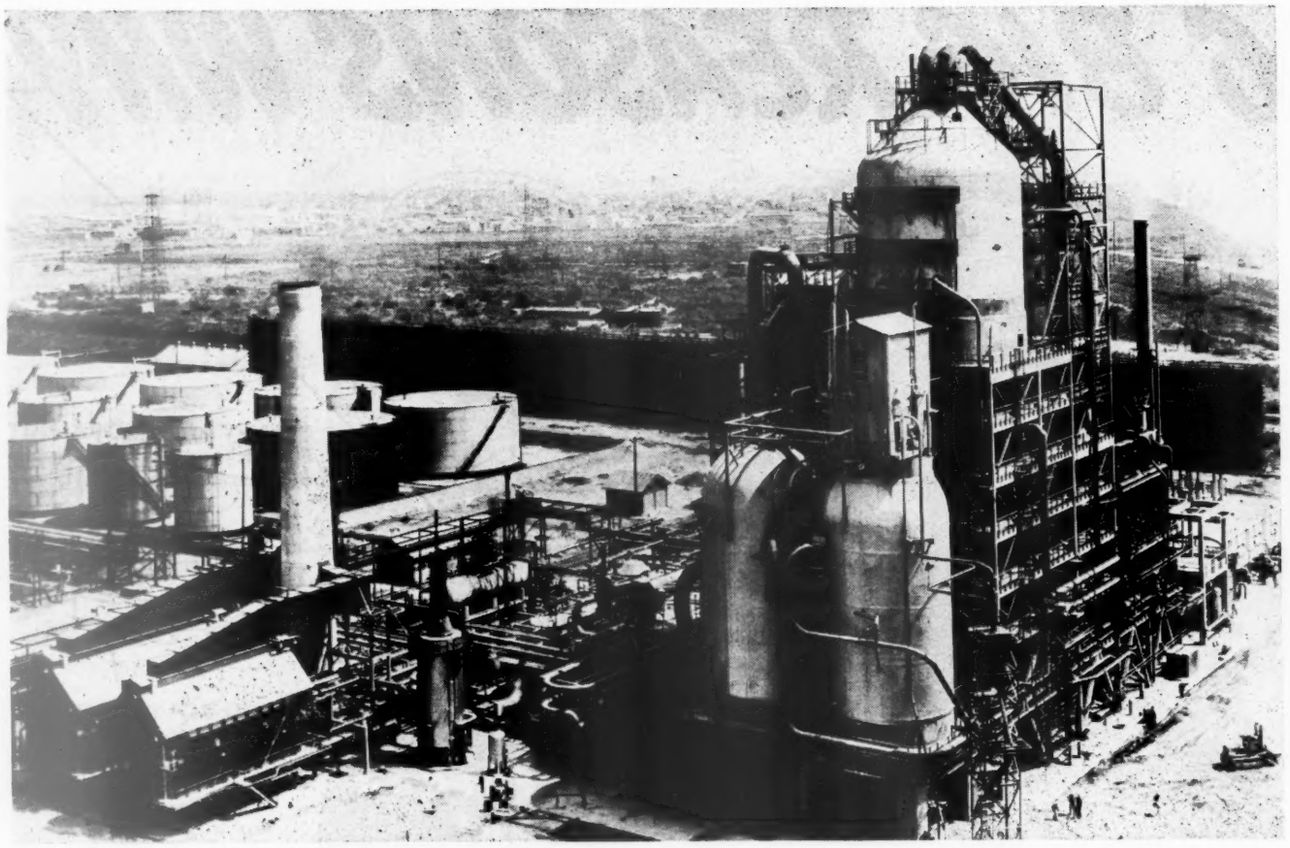

View of The Texas Company's fluid catalytic cracking unit at Wilmington, California.

tional mechanical design information so that improved equipment could be built for succeeding installations and existing ones altered to give better operation. Third, to provide extensive commercial data on processing in general, which would be helpful to the operating company in determining optimum conditions for its particular unit.

As a result of this policy, better design features have been incorporated in succeeding units until today fluid catalytic crackers exhibit stream efficiencies of more than 90 per cent, maintenance costs of less than 4 per cent per year of the investment cost of the unit, and a high degree of safety and stability in operation.

Obviously, the stream efficiency factor, i.e. the number of operating days per run divided by the total number of days in the run plus the days required to turn around the unit, is a very important consideration in the economics of an operating plant; in many cases it becomes the most important factor in deciding the survival of a process. Each day the unit is not operating represents the loss of thousands of dollars of production not to mention the additional expense of repairs. It should be borne in mind that stream efficiencies are markedly influenced by factors over which the process itself has no control. For example, labor strikes, failure of utilities, acts of God, manpower shortages, and the like all react detrimentally to stream efficiencies. Despite these, however, it is gratifying to find that the average last cycle stream efficiency for all Kellogg designed fluid units is currently 89.4 per cent, and that the average period of continuous performance has been 208 days. One particular unit has been in operation more than 520 days without a major turnaround. It was shut down once during this period because of a strike but no repairs were made. Table 1 lists typical stream efficiencies for a representative group of fluid catalytic cracking units.

TABLE 1

Typical stream efficiencies for fluid catalytic cracking units.*

Unit	Run no.	Operating days	Down time days	Stream efficiency, per cent
A	5	191	20	91
B	4	224	20	92
C	4	200	21	91
D	3	223	16	93
E	2	300	21	94
F	1	334	32	91
G	4	213	22	89

*Data based on Kellogg units only.

Based on this performance, most of the operating companies have revised their established scheduling procedures and are currently operating the FCC units on the plan of 12 months of continuous operation before bringing them down for inspection. Such scheduling permits the adoption of seasonal shutdowns so as to take advantage of weather and labor conditions.

The long runs and high stream efficiencies attainable by FCC units are the direct result of proper basic design and a high development of operating technique and control. For instance, catalyst carrier lines are designed for smooth uninterrupted flow; sharp bends are avoided; piping is kept to a minimum; catalyst velocities in vessels are maintained at such values that erosion is minimized. Although all these factors operate in reducing maintenance and repair, it should also be pointed out that the possibility of explosions or fire damage in FCC units is practically negligible due to the low operating pressure and the small inventory of oil vapor at any one time. The operating technique of the process, too, is such that normal operations can be resumed almost immediately following a utility failure or other simple stoppage.

Although great improvements have been made since the earlier FCC units went on stream, it is interesting to review the causes of shutdowns in previous operations.

Distribution of shutdown causes.*

	Per cent of total
Scheduled shutdowns	40
Utilities and miscellaneous	32
Slide valves	8
Injector and line erosion	8
Blowers	5
Regenerator linings	5
Expansion joints	2
	100

*Data based on Kellogg units only.

In other words, 72 per cent of all shutdowns were either scheduled or due to conditions over which the process had no control. With respect to the remaining 28 per cent, increased experience of operating crews and minor revisions in

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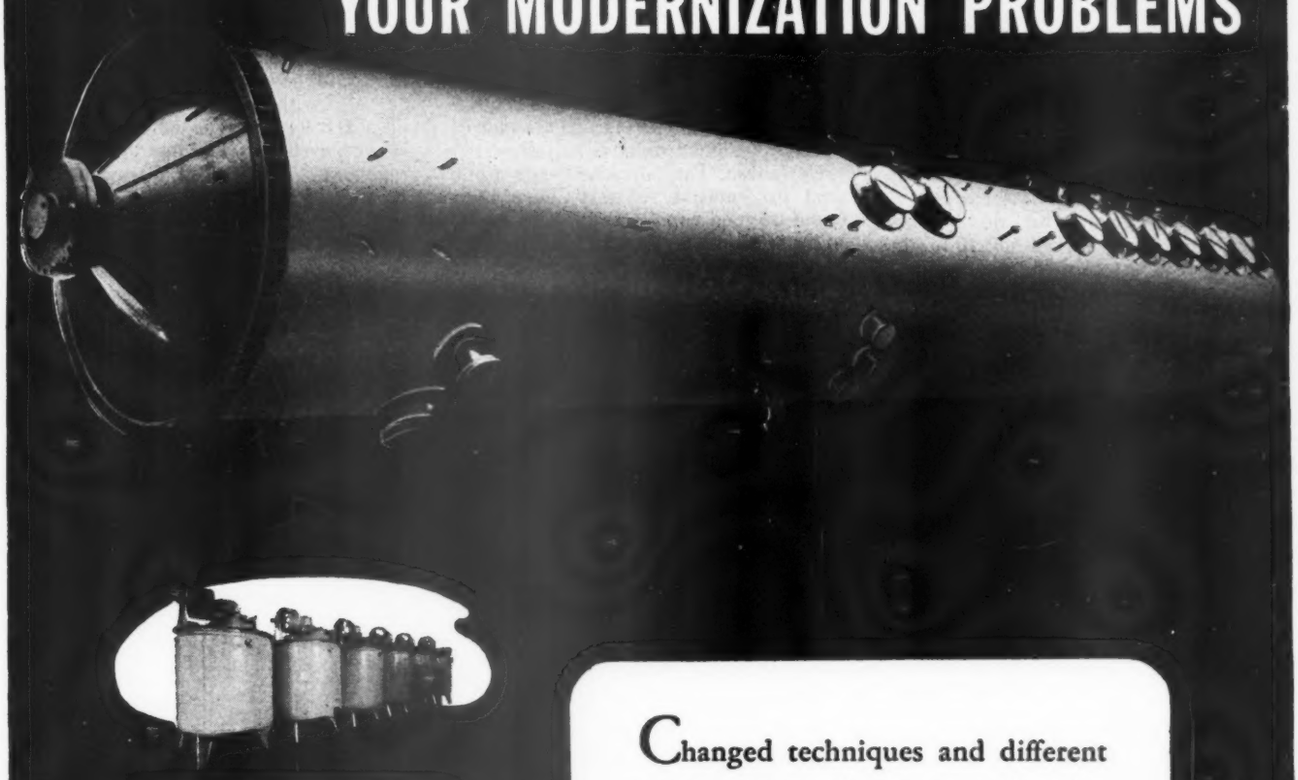

TANKS...
- WATER
- GASOLINE
- ACID
- PROPANE
- BUTANE
- CHLORINE
- BLENDING
- MIXING
- CRUDE

TOWERS...
- ABSORBERS
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equipment design have radically reduced this percentage in current units.

Turnarounds so affect the economics of refinery operation that they are always preceded by a careful program of planning and organization. A master list of items requiring inspection is prepared well ahead of time, and if any changes or additions are planned, engineering drawings are prepared and all necessary materials obtained. Necessary construction equipment such as welding machines, air compressors, tuggers, etc., are brought to the unit. Scaffolding to reach parts of equipment not supplied with catwalks is built before the actual shutdown. Work lists, time estimates, manhour requirements, and the like are prepared by the refinery staff. Blinding locations are established, and flanges are tagged ahead of time so that fitters can find points to be blinded without waste of time. Flanges and other points requiring attention due to leaks, etc., are tagged by the operators so that they can be quickly found when the unit is off stream. The result is that when "T-Day" arrives, everything is in readiness for work to proceed with precision and dispatch.

At the time set for the unit to go off stream, oil feed is cut out of the system, steam is blown into the reaction system and fractionator, and catalyst is circulated until regenerated. The catalyst in the reactor is then blown to the regenerator and cooled. When the temperature of the unit has fallen to a predetermined level, storage hopper lines are opened and the catalyst drops from the regenerator. The cooling process is rather rapid, and the catalyst unloading time, ordinarily, is quite short. The complete removal of catalyst, however, is an important factor in shortening the down time and in minimizing the manhour requirements of the turnaround. Improved techniques for close to 100 per cent removal have been devised.

As soon as the catalyst is out of the system, the removal of manheads is started and the equipment made ready for inspection. The total elapsed time up to this point normally is from 16 to 18 hr.

All key points in the system should be inspected during a turnaround, whether or not experience indicates the necessity. These include:

(a) Slide valves.

(b) Principal catalyst carrier lines.

(c) Tubular equipment through which catalyst flows.

(d) Fractionation system, including towers and tubular equipment.

(e) Slurry pumps.

Experience has proved that a detailed inspection of other equipment and lines is now practically unnecessary and therefore very little manpower must be budgeted for this purpose. Proper craft distribution is important, and Table 2 may be used as a guide.

A summary of the condition of equipment encountered during turnarounds of Kellogg designed units is as follows:

Cyclones. The cyclone separators, used for catalyst recovery, have been found in good condition. In some cases, slight erosion has been noticeable in the lower part of the separator but this wear has not been sufficiently serious to affect the operation of the units. The low erosion encountered is due to the fact that Kellogg units are designed for low gas velocities, resulting in decreased wear, yet maintaining adequate recovery efficiencies.

Regenerators. The overhead lines leaving the regenerators exhibit very little erosion since proper pipe diameters, elimination of sudden changes in direction, and catalyst velocities have been adjusted with this in mind. The adoption of a retractable type of cooling water spray nozzle in the upper part of the regenerators has removed a troublesome maintenance problem. These spray nozzles have given very efficient performance and can be easily serviced while the unit is in operation. The suspended

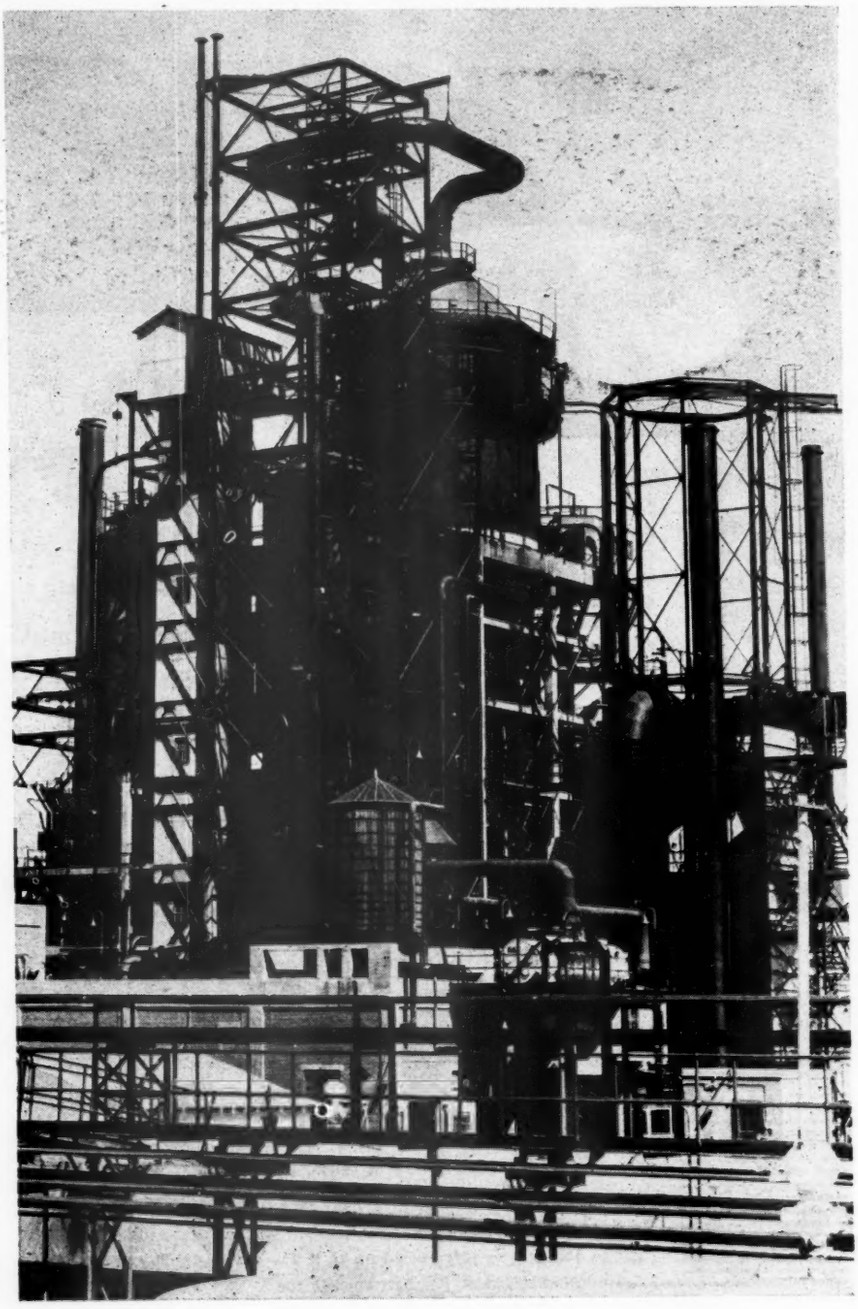
TABLE 2

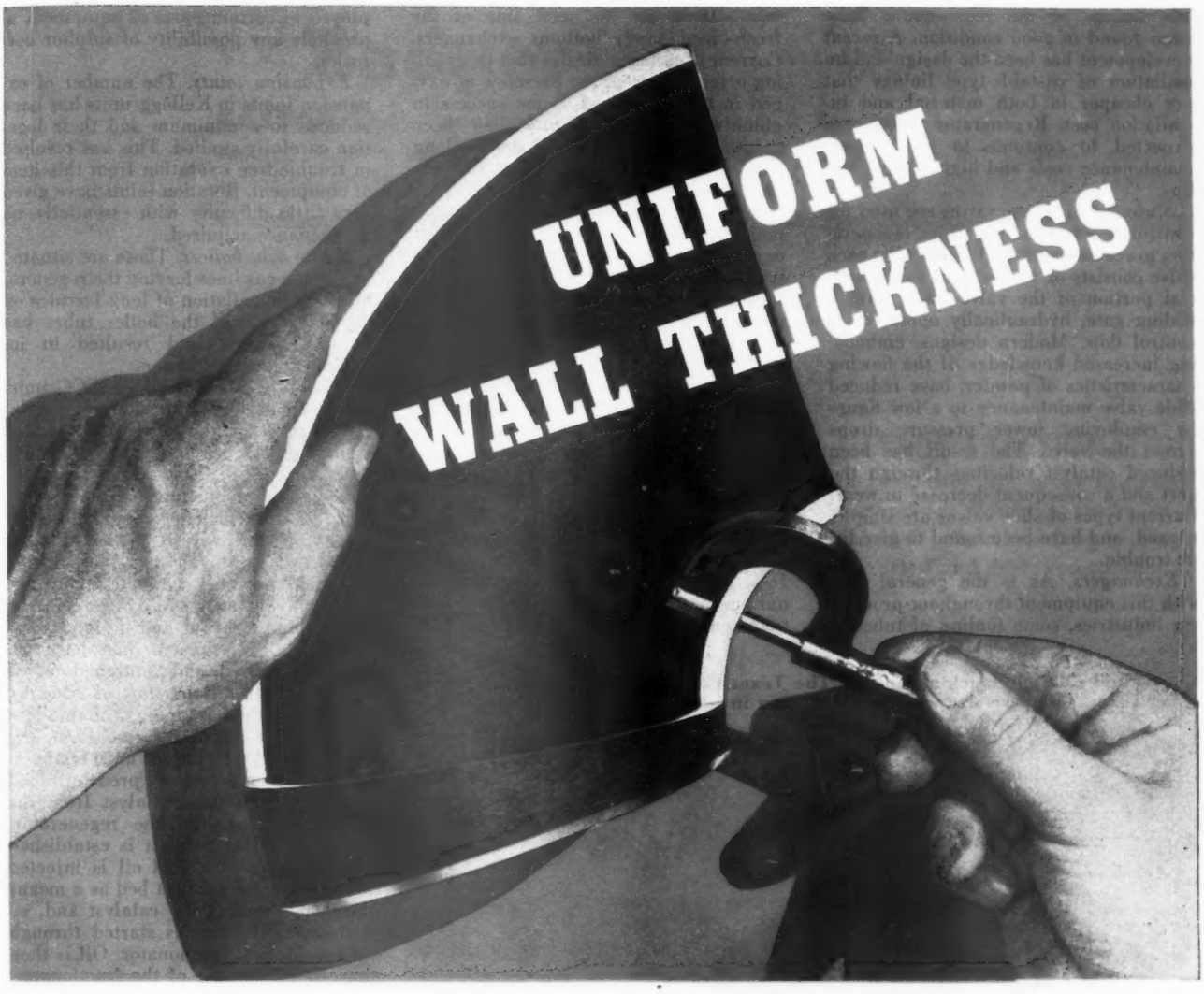
Typical craft distribution for FCC unit turnarounds.*

Craft	Per cent of total
Pipefitters	23
Riggers	11
Welders	11
Laborers	10
Boilermakers	10
Machinists	8
Insulators	6
Carpenters	5
Instrument men	4
Electricians	3
Painters	3
Brick masons	1
Miscellaneous	5
	100

*Based on experience with Kellogg units only.

Sinclair fluid catalytic cracking unit at Sinclair, Wyoming.





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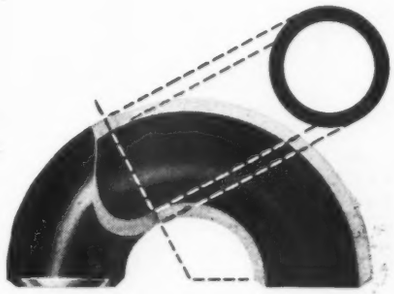

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tile linings of the regenerators have been found in good condition. A recent development has been the design and installation of castable-type linings that are cheaper in both material and installation cost. Regenerator vessels are expected to continue to show small maintenance costs and high service factors.

Slide valves. These valves are used for control of catalyst flow from regenerators to reactors and back. Basically, each valve consists of a fixed port in the central portion of the valve body, with a sliding gate, hydraulically operated, to control flow. Modern designs, embodying increased knowledge of the flowing characteristics of powder, have reduced slide valve maintenance to a low figure by employing lower pressure drops across the valve. The result has been reduced catalyst velocities through the port and a consequent decrease in wear. Current types of slide valves are simple, rugged, and have been found to give little trouble.

Exchangers. As is the general rule with this equipment throughout processing industries, some fouling of tubes is encountered on the feed side of the fresh-feed-tower bottoms exchangers. Current thinking indicates that this fouling originates from the presence of oxygen in the fresh feed. Some success in eliminating this difficulty has been gained by the injection of steam along with the feed at the inlet to the exchangers.

Fractionators. Today, no coking problems are encountered in this item of equipment, due to the removal of the internal bend attached to the vapor inlet line. This change resulted in the elimination of hot metal temperatures, which were conducive to coke formation.

Catalyst piping. The elimination of the internal linings of regenerator piping, through better mechanical design, has removed a former source of trouble. A superior, unlined piping now available and incorporated in current units has given excellent service.

Corrosion. Corrosion has not been a problem in any of the FCC units, even though some charging stocks contain 1½—2 per cent of sulphur. In those units where sour charge stocks were anticipated, alloy linings have been employed in certain parts of equipment to preclude any possibility of sulphur corrosion.

Expansion joints. The number of expansion joints in Kellogg units has been reduced to a minimum and their location carefully studied. This has resulted in trouble-free operation from this item of equipment. Rotation joints have given very little difficulty with essentially no maintenance required.

Waste heat boilers. These are situated in the flue gas lines leaving the regenerators. The installation of long ferrules on the inlet side of the boiler tubes has reduced erosion and resulted in increased steam production.

Feed preheaters. Kellogg FCC units are designed to operate with only partial vaporization of the feed stock, which eliminates any coking problem in the preheaters. This also permits wide latitude in choice of charging stocks and high stream efficiencies regardless of quality of feed.

Reactor. Inlet and exit line erosion presented the only possible difficulties here, and were successfully overcome by proper piping layout and design.

When all equipment has been inspected, repaired, and "buttoned-up," it is made ready for the start of cracking operations, which is, again, a simple routine of valve manipulations. First, the unit is heated with hot air until temperatures have reached a predetermined level, at which time catalyst from the hoppers is fed into the regenerator. When a level of catalyst is established in the regenerator, fuel oil is injected directly into the catalyst bed as a means of further heating the catalyst and, simultaneously, steam is started through the reactor and fractionator. Oil is then charged to the base of the fractionator, and tower bottoms circulation is established. As soon as sufficient catalyst is in the regeneration system and all temperatures are at the desired level, catalyst circulation is started and fresh feed is started to the system a short time later. A start-up normally takes 22-24 hr.

The manhours required to turn around a fluid catalytic cracking unit are dependent on several factors. Other things being equal, however, proper design of the unit in key sections will reduce this turnaround outlay to a minimum. The latest improvements in design that have contributed to reduced maintenance requirements are:

(a) Elimination of internally lined catalyst carrier piping.

(b) Elimination of trouble spots in piping and bends.

(c) Reduction of gas velocities in lines subject to extensive erosion.

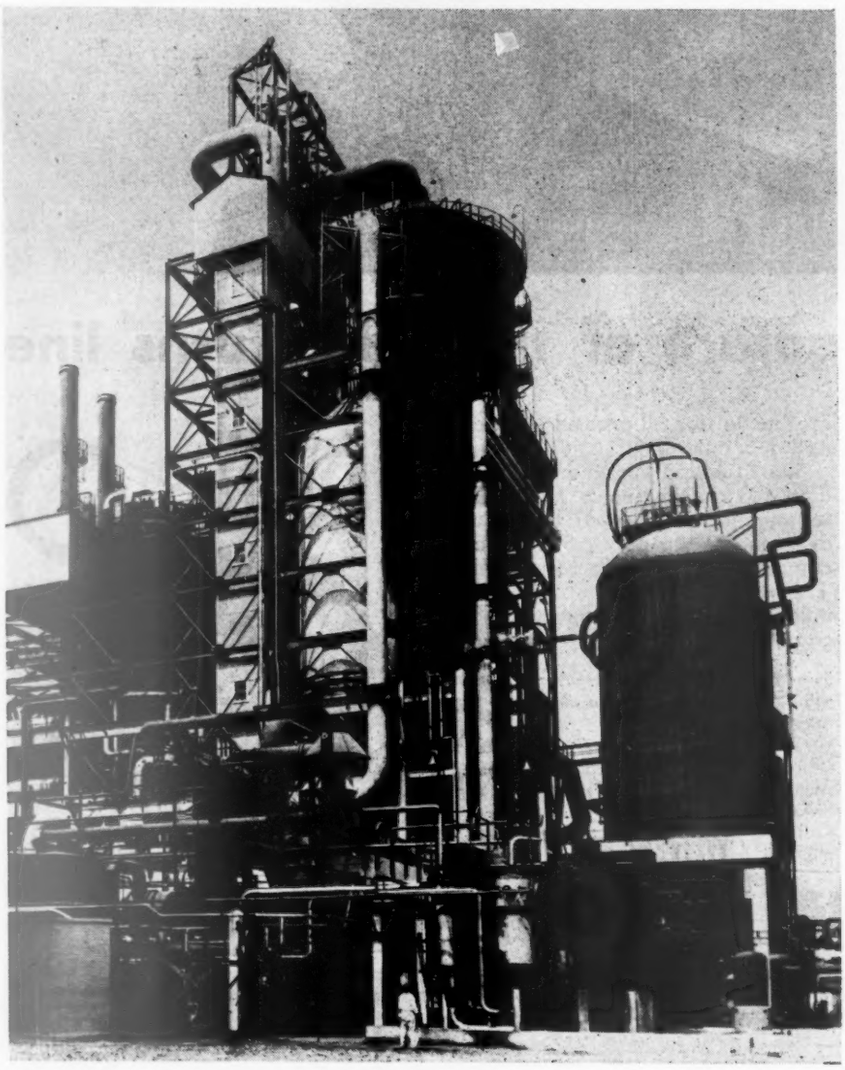
(d) Reduced slide valve pressure drops.

(e) Improved precipitator equipment.

Despite good design, however, faulty operation can result in excessive equipment wear and increased maintenance costs. Therefore, such variables as steam flows, temperatures and pressures, which can materially affect the life of the equipment, should be controlled by

(Continued on Page 108)

Fluid catalytic cracking unit of The Texas Company at Port Arthur, Texas. Compare size with figure of man in white, center foreground.



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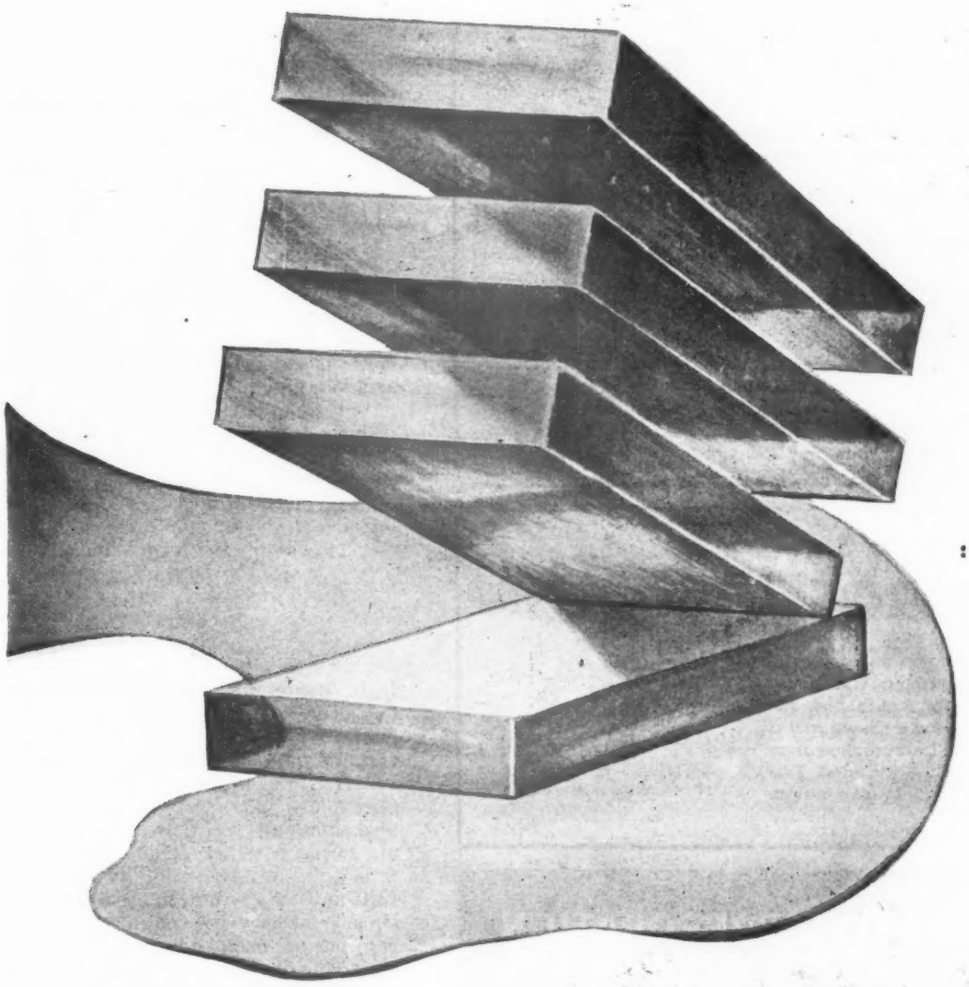

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(Continued from Page 104)

the extensive use of automatic control instruments, and operating personnel should be carefully trained to take proper precautions against the overloading of equipment.

Table 3 presents some available information on the manhours required for turnarounds of FCC units of various sizes when operating for the production of aviation gasoline base stocks. Such units were also operated for high yields of butylenes for the synthetic rubber program, and required gas oil cracking at extremely high conversion levels.

TABLE 3

Turnaround manhour requirements, aviation gasoline production.

Throughput for aviation gasoline, bbl. per day	Turnaround manhours, range
8,500	10,000–21,000
10,000	17,700–26,000
16,000	16,000–60,000

It is known that these figures are greatly in excess of the requirements necessary for current operation. The same units, when operating for motor gasoline production, have a capacity almost double that for aviation gasoline production, without any increase in maintenance costs. Therefore, the maintenance requirements for motor gasoline production are not expected to exceed the figures shown in Table 4.

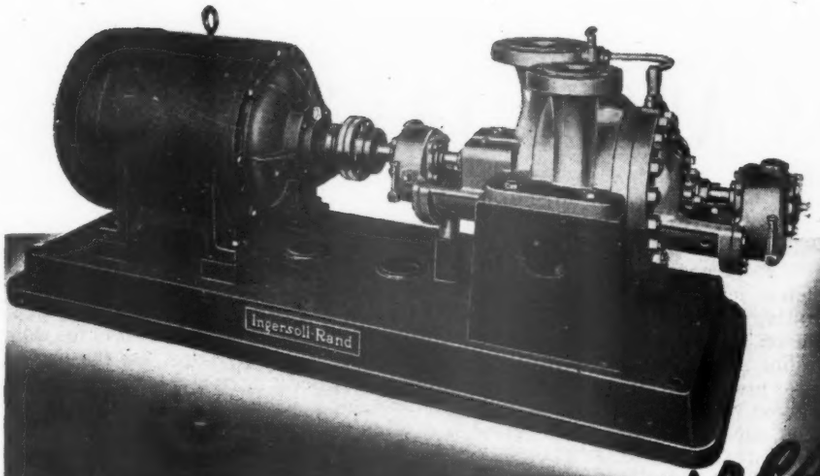
TABLE 4

Turnaround manhour requirements, motor gasoline production.

Throughput, bbl. per day	Turnaround manhours
5,000	6,000
8,500	10,000
10,000	12,000
16,000	19,000
28,000	34,000

It follows that the maintenance cost per barrel of throughput is markedly less when the FCC unit is operating for motor gasoline production than it is for aviation gasoline production. Substantiating this conclusion is the fact that maintenance costs, including materials, for currently operating FCC units are approximately 3.5 per cent per year of the original investment cost. This figure includes the maintenance costs for normal operation and turnarounds. Even better results are hoped for in the immediate future due to further improvements in design and operation.

In view of the continuing demands for increasingly better quality motor fuels, it now appears certain that the backbone of a modern integrated refinery is the "cat cracker." It therefore becomes imperative that such units give reliable and continuous performance, for "spotty" performance and unscheduled shutdowns seriously affect the manufacturing cost per gallon of gasoline. It is gratifying to be able to state that FCC units are setting new standards of stream efficiency and continuously lower per barrel maintenance costs — both major factors in the economics of competitive refining operations. ★ ★ ★



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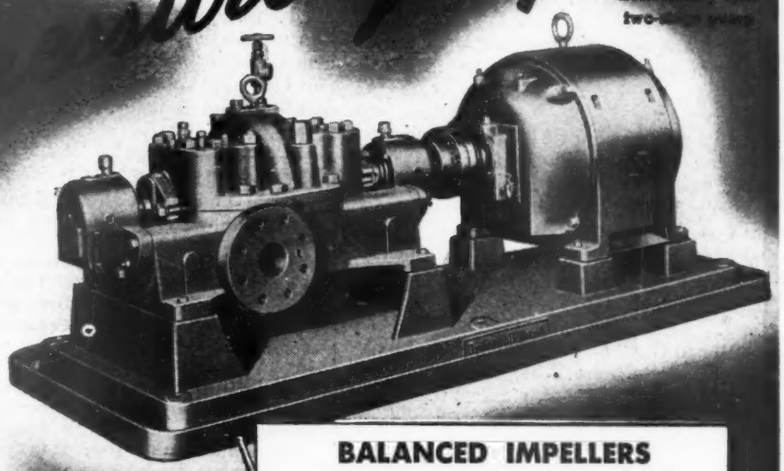

The complete line of I-R refinery pumps includes units for practically every service. Where the operating conditions involve pressures beyond those that can be handled efficiently and reliably by a single-stage pump, there are I-R two-stage centrifugals such as the units illustrated, also multi-stage units for still higher pressures.

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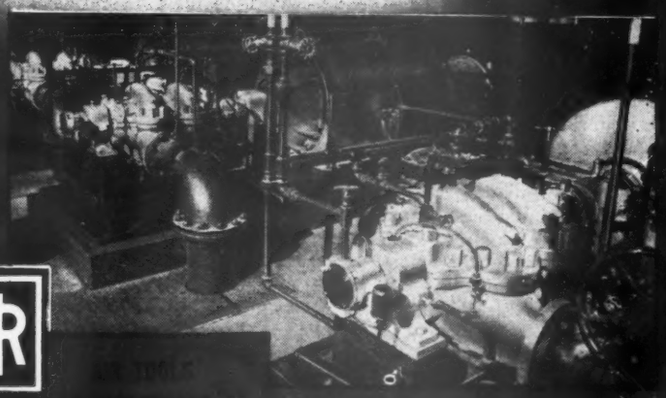

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CAMERON PUMP DIVISION

QUESTIONS ABOUT TAXATION

By **SAM THOMPSON**

PROBLEMS are submitted to the Petroleum Accountants Society of Dallas, Texas, at its regular monthly meetings for round-table discussion and solutions when possible. Certain representative problems, together with the unofficial answers, are given herein and will be published each month if sufficient reader interest is indicated.

Discussion and questions from the readers are invited. Please support any criticism by proper references to the code, etc.

Problem:

"X" sold a lease for $10,000 cash, and reserved an oil payment for $30,000. "X's" basis in the property was: Leasehold cost $2000; and net equipment (asset less depreciation reserve) $15,000.

Question: Does "X" have any tax to pay on the transaction?

Answer: No.

Proof:

Refer to G. C. M. No. 23623, page 313 of Internal Revenue Bulletin—Cumulative Bulletin 1943; also the Fleming (Mrs. William, et al) case 36-1 USTC Par. 9165-1936 CCH, printed below for convenience:

Summary:

Divide cost of "X's" interest in the property before the transaction, between the interest sold and the oil payment retained, on a basis of the comparative values of the two interests.

Any gain on the sale is subject to section 117 of the code (Capital Gains Section). (In this case none.)

The cost of the equipment is recovered first. (All the $10,000 cash received recovers part of the cost of the equipment in this case). Any excess of cash received is considered the sales price of the depletable asset. (None.)

Any unrecovered depreciable cost ($5000) is added to the depletable basis ($2000) making the new basis of the property retained, the oil payment, $7000.

No loss would be recognized. (Here there is none.)

Depletion is allowable on the oil payment receipts at cost or statutory whichever is the greater.

G. C. M. 23623

Internal Revenue Code and Prior Revenue Acts.

The decisions of the United States Circuit Courts of Appeals for the Fifth and Tenth Circuits in Columbia Oil and Gas Company v. Commissioner (118 Fed. (2d), 459) and Commissioner v. H. W. Lewis (132 Fed. (2d), 709) respectively, relating to the proper treatment for federal income tax purposes of a cash payment received as consideration for the assignment of an operator's interest in oil and gas properties, including depreciable equipment used thereon, in cases in which the contract entitles the assignor to in-oil payments out of production from the properties in addition to the cash paid upon assignment, should be followed in cases involving that issue.

Application of the rule stated in the cited cases.

Attention has been invited to the recent decision of the United States Circuit Court of Appeals for the Tenth Circuit in Commissioner v. H. W. Lewis (132 Fed. (2d), 709), citing the decision of the United States Circuit Court of Appeals for the Fifth Circuit in Columbia Oil and Gas Company v. Commissioner (118 Fed. (2d), 459) involving an identical issue. Advice is requested whether those decisions should be followed in cases containing the same issue.

THE AUTHOR

Sam Thompson obtained his accounting and tax education from Southern Methodist University and from public accounting firms with which he was associated for several years. He was the first president of the Petroleum Accountants Society of Dallas, and is now serving as an ex-officio member of the board of directors of that organization. He is currently the secretary-treasurer of several oil corporations, handling all federal tax matters, and is accounting officer for several partnerships, a few individuals, and 23 trusts.

The cited decisions are in accord on the issue concerning which advice is requested. The issue involves the proper treatment for federal income tax purposes of a cash payment received as consideratoin for the assignment of an operator's interest in oil and gas properties, including depreciable equipment used thereon, in cases in which the contract entitles the assignor to in-oil payments out of production from the properties in addition to the cash paid upon assignment. The decisions hold that a cash payment, to the extent of the assignor's depreciated cost of the assigned equipment, should be treated as proceeds from the sale of such equipment, thereby allowing the assignor the tax-free return of his depreciated cost of such equipment. With respect to the remainder of any cash payment, both courts held that it represented proceeds from the sale of the operator's interest in oil and gas in place, less the oil payment rights reserved by the seller. The cost of the interest sold (the operating interest less the retained in-oil payment rights) was held to be the total cost to the seller of his operating rights, less the fraction of such cost attributable to the retained interest. Such total cost of the whole interest was allocated between the interest sold and the interest retained on the basis of the comparative values of such interests as of the date of assignment.

The cited decisions are believed to be sound, and they should be followed without further litigating the issue. Care should, of course, be exercised in confining the application of the stated rule to those cases in which the assignment effects a sale, as differentiated from a transaction in which the assignor or sublessor retains a royalty interest throughout the productive life of the property, as in Palmer v. Bender (287 U. S., 551, Ct. D. 641, C. B. XII-1, 235 (1933)). (See G. C. M. 22730, C. B. 1941-1, 214, for the distinction between a sale and an assignment or sublease in which the assignor or sublessor retains a royalty interest.)

It should also be noted that the stated rule should not be applied in any case so as to produce a deductible loss on the sale of depreciable equipment. In cases in which the cash payment is less than the depreciated cost of the depreciable equipment passing by assignment, the excess of such cost over the cash payment represents part of the depletable cost of the retained economic interest, or interests, in oil and gas in place. As is well known, operating properties are sometimes disposed of by assignment without any cash payment being made for the assignment, and yet such assignments are classified as sales. (See G. C. M. 22730, supra.) It seems apparent that in such cases the entire cost of the assignor, including cost of depreciable equipment on the property represents cost of the interest retained.

There is nothing in the cited decisions that tends to dispute the suggested qualifications to the rule applied to those cases.

J. P. WENCHEL,
Chief Counsel, Bureau
of Internal Revenue.

Mrs. Wm. Fleming, et al

Upon sale of Texas oil leases for cash and a share of the oil when produced, the vendor is not entitled to percentage depletion as to the cash received, as such money payment, unconnected with production of oil, is to be dealt with as representing a conversion of capital by sale; but be is entitled to the percentage depletion deduction as to his income from sale of oil produced. Dissenting opinion filed.

★ ★ ★

COMPUTING QUANTITIES OF OIL PRODUCTION AND PIPE LINE RUNS

By **W. F. MARTIN,**

Texoma Natural Gas Co.

EXCLUSIVE

SEVERAL years ago the writer had charge of a field production office in Greenwood County, Kansas. There were quite a number of oil pumpers in this district and therefore numerous production reports.

Pumpers are not necessarily mathematicians, and errors would creep into these reports and not be detected by the various farm bosses. As the farm bosses reported by telephone, there was no way for the field office to detect the errors until the production reports came in, and then it was too late because the field office had made its report on the basis of telephonic information.

To remedy this situation, the writer devised a computer for company pumpers and farm bosses that relieved them of all mental effort in calculating production. This computer consisted of 2 dials and an arm, with instructions regarding its use shown on the face of upper dial. The lower dial contained "feet and inches" in the tank; the upper dial contained production in barrels for 65 (130), 105 (210), and 250 (high 500) bbl. tanks, an arrow to indicate "yesterday's gage," and instructions; the arm contained tank sizes.

Operation: The arrow on upper dial is pointed toward "yesterday's gage" on lower dial; arm is moved to "today's gage" on lower dial; and "today's production" is read on upper dial immediately above "tank size" on arm in barrels of oil.

After providing pumpers and farm bosses with these computers, the accuracy of production reports was measurably increased. The time required for making the reports was also decreased.

The successful use of this computer gave rise to another idea that would speed the paper work in connection with production and pipe line runs from production tanks. The tanks the writer has in mind are steel cylindrical tanks only, the sides of which are perpendicular to the bottom.

The writer has checked numerous tables for these tanks and finds the deadwood to be spread equally over the height of the tank. This being the case, computers similar to the field computers could be used to good advantage in the office. On the upper dial there would appear what would be called a "base fig-

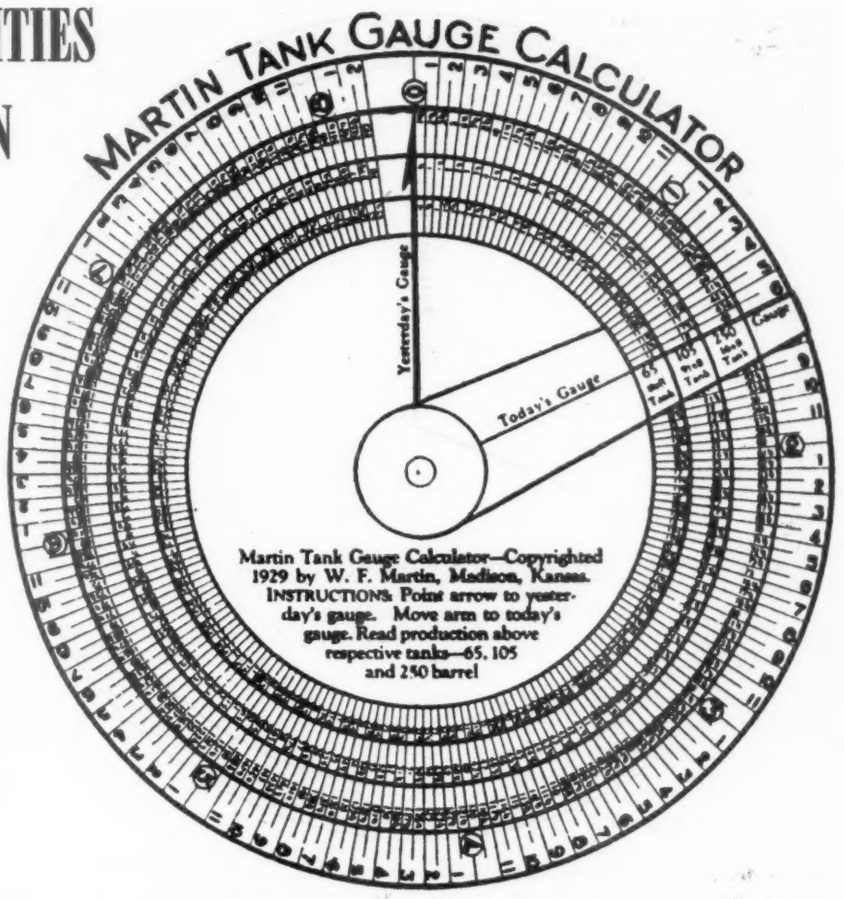

MARTIN TANK GAUGE CALCULATOR
Yesterday's Gauge
Today's Gauge
Martin Tank Gauge Calculator—Copyrighted 1929 by W. F. Martin, Madison, Kansas.
INSTRUCTIONS: Point arrow to yesterday's gauge. Move arm to today's gauge. Read production above respective tanks—65, 105 and 250 barrel

FIG. 1. Composite view of computer.

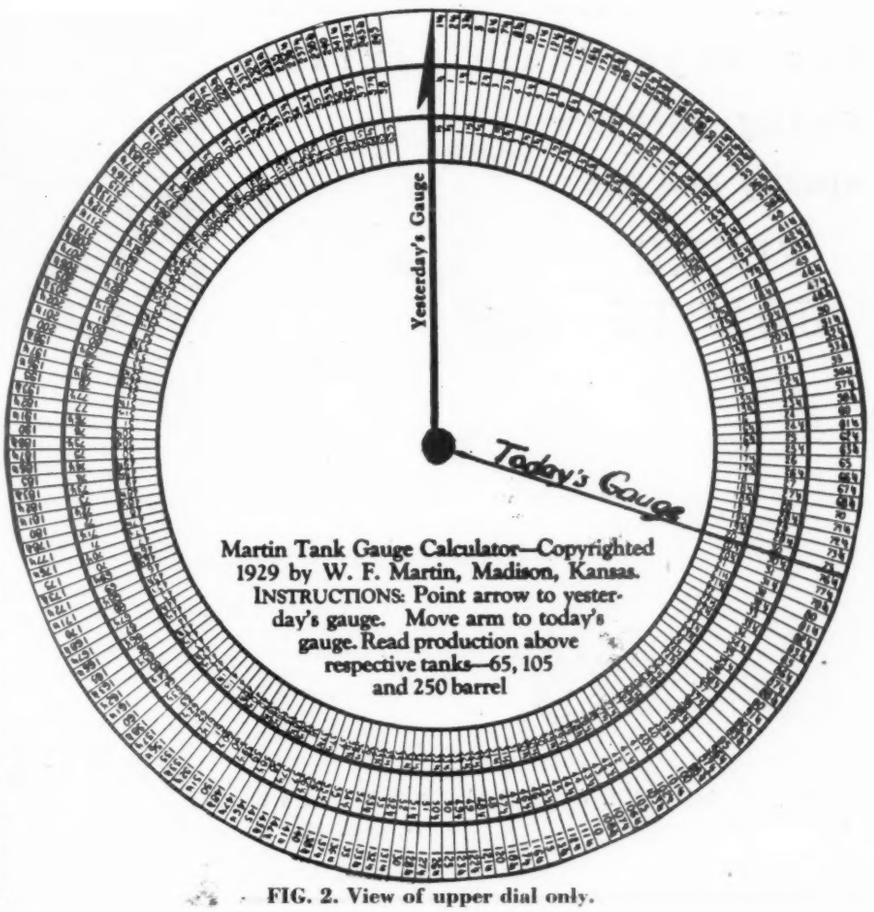
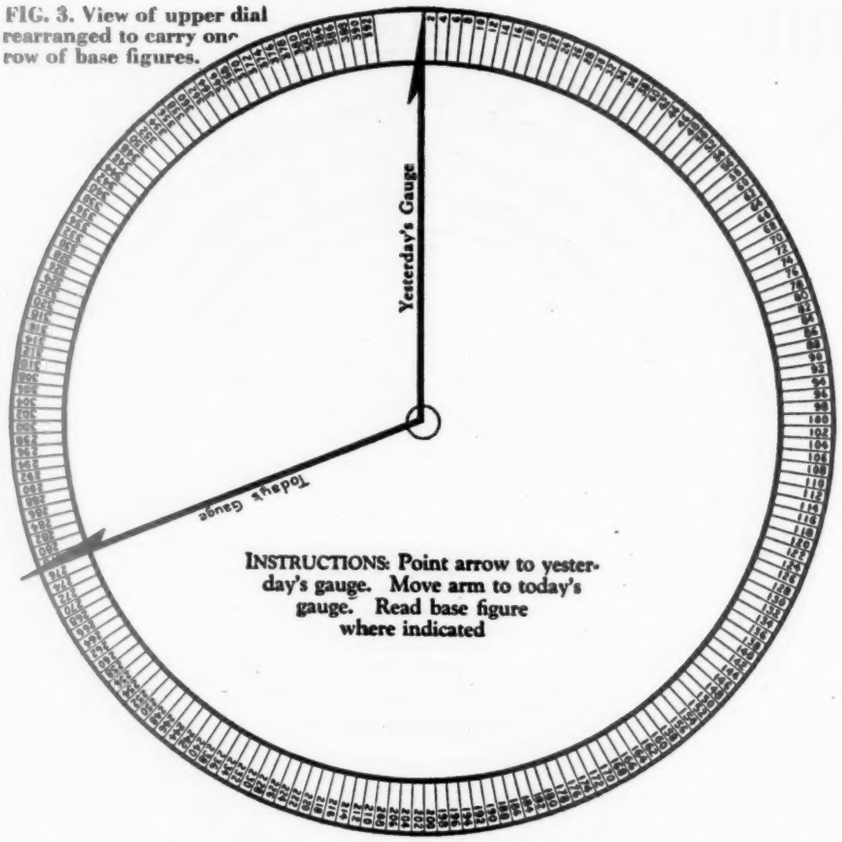

Yesterday's Gauge
Today's Gauge
Martin Tank Gauge Calculator—Copyrighted 1929 by W. F. Martin, Madison, Kansas.
INSTRUCTIONS: Point arrow to yesterday's gauge. Move arm to today's gauge. Read production above respective tanks—65, 105 and 250 barrel

FIG. 2. View of upper dial only.

FIG. 3. View of upper dial rearranged to carry one row of base figures.


Yesterday's Gauge
Today's Gauge
INSTRUCTIONS: Point arrow to yesterday's gauge. Move arm to today's gauge. Read base figure where indicated

ure" instead of barrels, and one row of base figures would suffice for all sizes of tanks. Fig. 3 is a view of upper dial rearranged to carry a row of base figures.

The use of a computer of this kind should greatly facilitate the computation of oil production and pipe line runs. A tabulation on one 8½-in. by 11-in. sheet of paper would take the place of many tank tables. The data would consist of tank number, tank size, and tank factor. Should a restrapping of tank reveal a change in measurement, the tank factor would be changed accordingly. Under the method now in use, a change in measurement would require a new tank table.

Under the suggested method, the procedure would be as follows:

A clerk would move arrow on upper dial to one measurement and, holding upper dial in place, move arm to the other measurement; take reading in "base figure," and note this reading together with tank factor on the production or run ticket. The production or run ticket would then be passed to a calculating machine operator for the extension—tank factor × base figure = barrels.

A tank table may be compared to an orifice meter chart extension table. The writer finds it simpler and faster to use an orifice meter computing chart for extensions.

Should this change in method be favorably received, a company draftsman could very easily prepare the "base computer," or a ruler company would be glad to make and supply them. Plastic is recommended as a material from which to make the computer. ★ ★ ★

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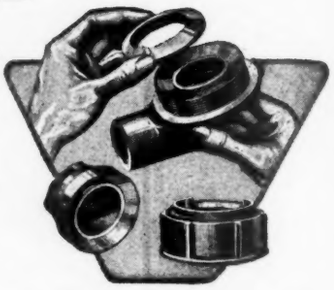

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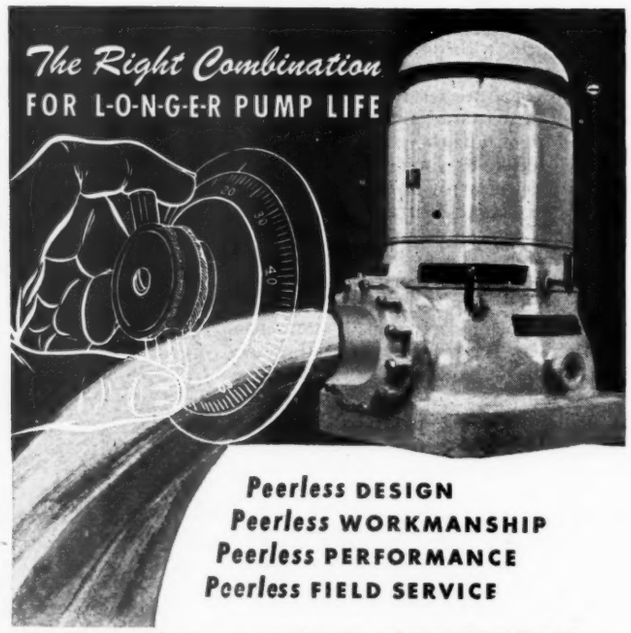

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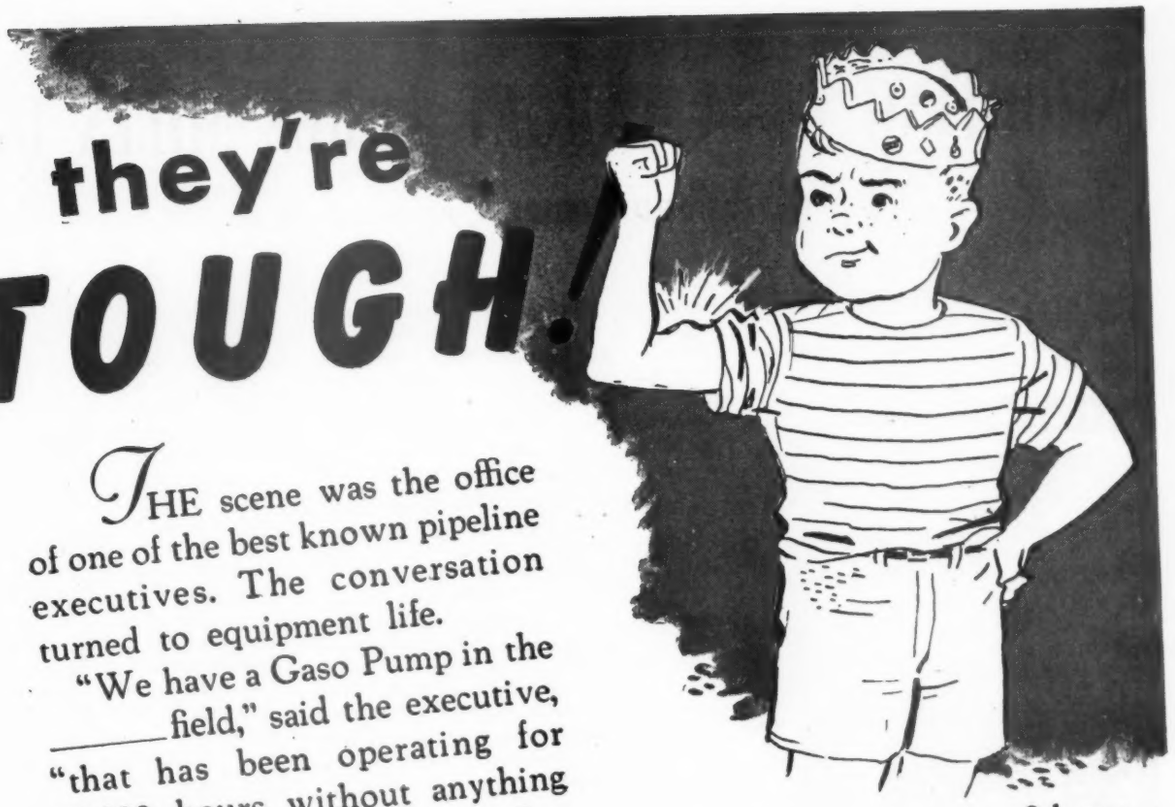

THE scene was the office of one of the best known pipeline executives. The conversation turned to equipment life.

"We have a Gaso Pump in the _____field," said the executive, "that has been operating for 35,000 hours without anything more than normal attention."

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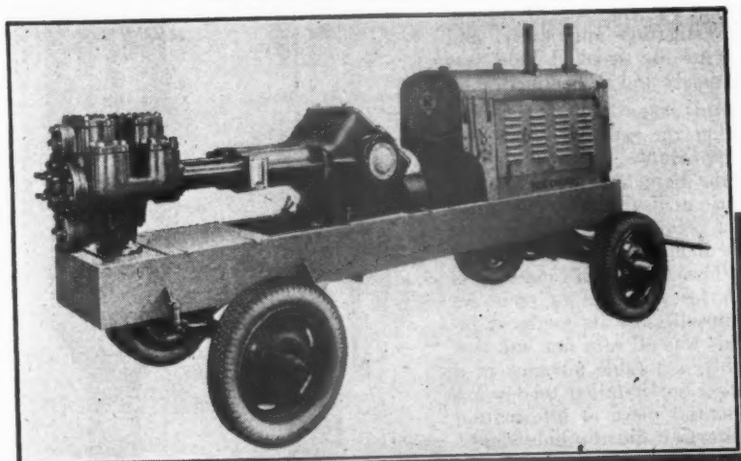

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SHOOTING AT A TARGET THREE MILES DOWN

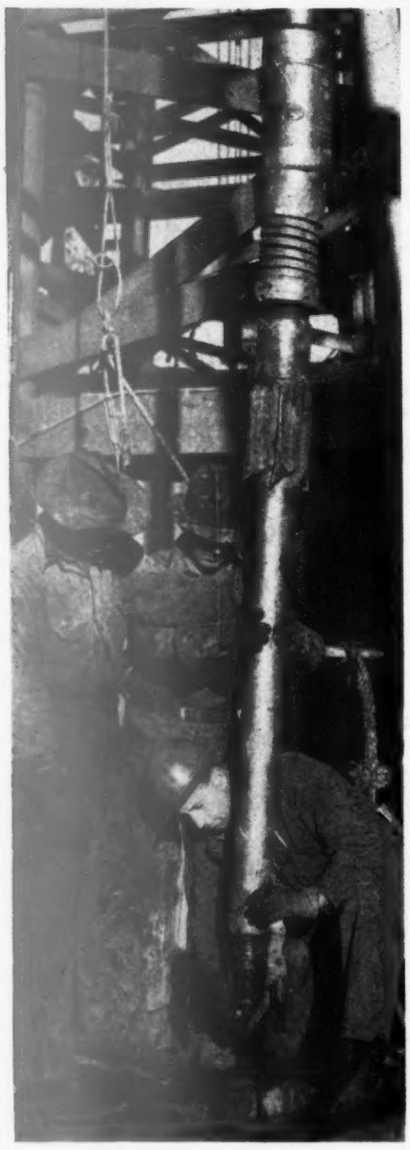
By **RICHARD SNEDDON,** *Pacific Coast Editor*

EXCLUSIVE

THERE was a time, incredible as it may seem now, when there were no such things as well surveys; when directional control of drilling was a virtual but certainly not a virtuous nil; when the bit was assumed to be going straight down, but as a matter of fact was following a distinctly devious route, known as "the path of least resistance." After a while, of course, the fact that the drill wasn't really going straight became known. It was manifested in divers amusing and amazing ways that provided the petrolic raconteurs of the day with some delectable bits for their already extensive repertoires. There were few, indeed, who couldn't, given the slightest encouragement, dig up a yarn or two about the weird meanderings of the predatory bits.

Some were reputed to have found their way into neighboring wells and unknown to the prior owners to have taken a liberal share of production over a number of years. Others are said to have started down in orderly manner, then curled back up again and gouged into the pipe lines, thus bringing in some very nice wells—a few of which actually produced refined products. One salubrious fishtail, the saga goes, even penetrated a beer vat and produced a frothy flow of amber liquid that was immediately identified by members of the drilling crew who had never had the slightest vestige of chemical training.

Checking marking on knuckle joint preparatory to running in the hole.

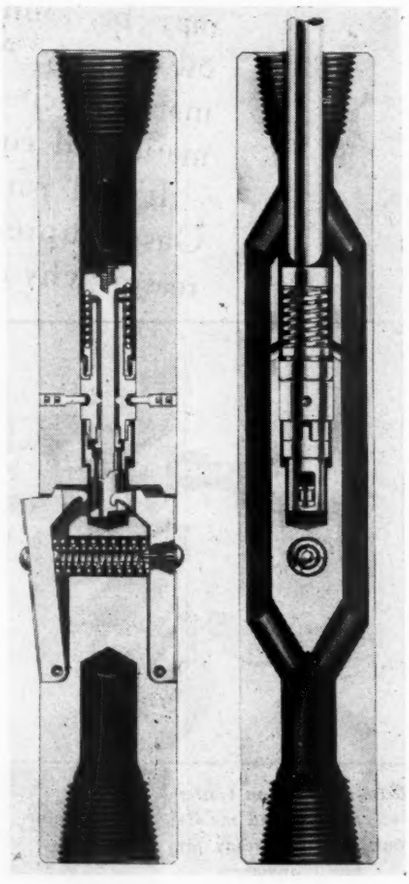


THAT, we repeat, was in the good old days when drilling was an adventure—not an operation; when operators were adventurers—not scientists; when owners were gamblers—not economists. Gradually, however, as the business of raising oil, refining it and distributing it, became more competitive, keener cognizance was taken of the many processes involved. Geologists, engineers, chemists began to examine a little more meticulously the practices of the various departments, and substitute logical procedures for haphazard methods wherever it might be done. Needless to say, drilling came in for a fair share of this questioning and revision. Tools and techniques became the subjects of intense scientific investigation and study, and the problem of the crooked hole was tackled vigorously and determinedly.

It was at this stage of petroleum development that the well surveyor first made his appearance, gaging the angularity of the bore hole with a bottle of hydrofluoric acid, the latter being introduced just before the bottle was lowered into the hole. At the test level the bottle was allowed to remain motionless long enough for the acid to etch the glass and thus disclose its angle of inclination. This was all very fine and was unquestionably a notable advance in a new technique, but it failed to develop one very essential piece of information—in what direction did the hole slant? Despite the elementary nature of this first attempt, however, and its overall inadequacy, it turned the attention of many scientists to the problem of orientation, with the result that in a comparatively short time technically precise surveying instruments were available.

These devices, in the hands of informed and qualified operators, are capable of giving accurate information regarding the degree of deviation from the perpendicular and the direction of the deviation, at any interval in the borehole. Thus, were established means of proving and measuring effects. But there were other essentials! While all this progress was being made, engineers were studying the prevalent drilling processes in all their aspects, to determine if possible the underlying causes of deviation and directional drift, and coincidentally to decide not how the wandering of the drill might be overcome—but, how it might be controlled. It became patent that the capacity to drill to a precise spot in the substrata by a preestablished and perhaps circuitous route, could un-

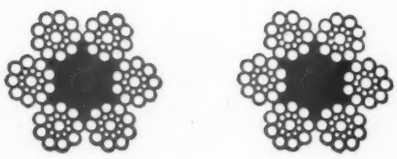
M-M-O retrieving sub showing bypass for circulation and, right, the sub with one latch open and one closed.



RUBIES

Two rubies, one real, the other synthetic, may look alike, yet differ in value.

and



ROPES

Two pieces of wire rope may be of identical construction yet differ in performance.

The purchaser of wire rope isn't buying wire rope, but the service that rope will render on the job. And wire rope performance is dependent not alone on its "construction" but upon the quality of the wire used in its manufacture.

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Every wire is drawn until it is accurate within a fraction of a thousandth of an inch . . . an important fact to remember since the performance and durability of wire rope is dependent upon accurate coordination of each component part.

Even though wire rope is tough, it is a delicate mechanism and as such is deserving of care to insure longer service. To help you get such service we have available an 82 page book packed with useful ideas for lengthening rope life. It's yours for the asking. And, if you have any problems regarding wire rope our engineers will be happy to help in their solution.

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der many circumstances be a distinctly profitable accomplishment.

Some operators studied the problem with the aid of miniature drilling outfits, constructed exactly to scale, and operated on small core sections under standard conditions. All sorts of research and scientific debate were aimed at the development of authentic data; and, from this concentrated thinking and doing, there eventually came a new understanding of directional control in drilling and new tools and equipment to carry it on. Today, we can almost select a spot three miles underground, well outside the periphery of the derrick floor, and in due course centerpunch it with a drilling bit.

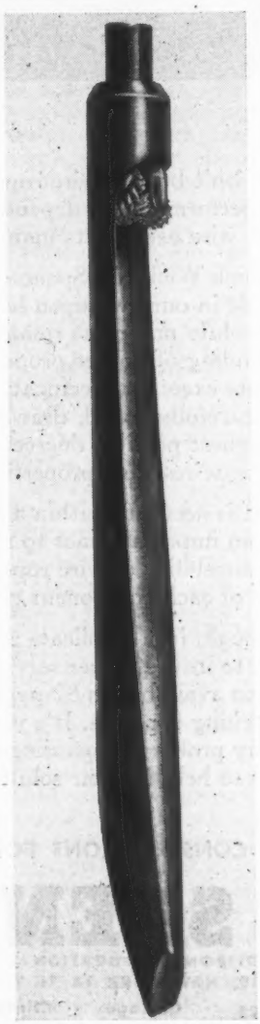
Slant drilling is so inseparably related to well surveying of a specific type that it is impossible to discuss one without the other. It is obvious that the deviation of the hole from the perpendicular and its directional drift at any significant interval must be known before any plan of further action can be projected intelligently. It may be true perhaps that a highly experienced and sensitive driller can by choice of bit, variation of rotary speed, and manipulation of weight successfully drill at an inclination and in a direction previously determined, but it is equally true that he can never know how successful he has been until a survey of the hole has been made. So, if circumstance points the necessity of drilling a slant well, there isn't much argument against the advisability of conducting the program on a scientific basis —of relying on measurement rather than supposition.

The functions of controlled directional drilling are many: It may be used (1) to circumvent the disadvantage of a poor site for a well foundation immediately over the oil reservoir; (2) to straighten an accidentally crooked hole; (3) to sidetrack a fish or other obstruction in the hole; (4) to kill a wild well; (5) to develop production from a formation that is more economically reached by a route other than that which follows a vertical line. There are many other reasons, of course, as, for example, the discovery of a fault and the necessity of reaching the sand at a different level and direction; the intrusion of a salt dome; the need to deviate upstructure to avoid water encroachment, and, finally, it may be employed simply for exploratory purposes, or to increase oil sand penetration.

IT IS probable that the one man more than any other to whom credit should be given for the scientific development of well surveying in California is Alexander Anderson, who about 1925 introduced a clock-worked camera and a series of pendulums, of which photographs were taken in the hole, the angularity of the bore and its direction being revealed by the attitude of the pendulum against a scaled background and the drift of the hole with reference to a north-south line on the derrick floor. The orientation of the surveying instrument was contrived by checking each stand of the pipe or tubing to which it was attached, against a distant object. By means of this devise Anderson demonstrated that supposedly vertical wells had a substantial horizontal drift, and he awoke the operators to the logic of using surveying instruments as an adjunct of the drilling process.

Thenceforth there was a positive epidemic of new methods and new equipment for the determination of inclination and directional drift. In the course of time, however, many of these fell by the wayside, and only those that were scientifically sound survived. Today a number of inclinometers, and single-shot and multi-shot directional instruments are available, either as individual units or in combination. There are two general methods of gaging deviation from the perpendicular, the puncturing method and the electro-chemical method, both using a suspended plumb-bob to determine the inclination. In the puncturing instrument the nose of the plumb-bob actually makes an indentation or perforation on a printed chart, with which it is brought into contact. Timing is controlled by a clock. In the electro-chemical method, a weak current of electricity travels down the plumb-bob, and when it is at rest makes an easily readable indication on a preprinted, specially sensitized chart. No development of this record is necessary and no time clock is used.

Removable whipstock.



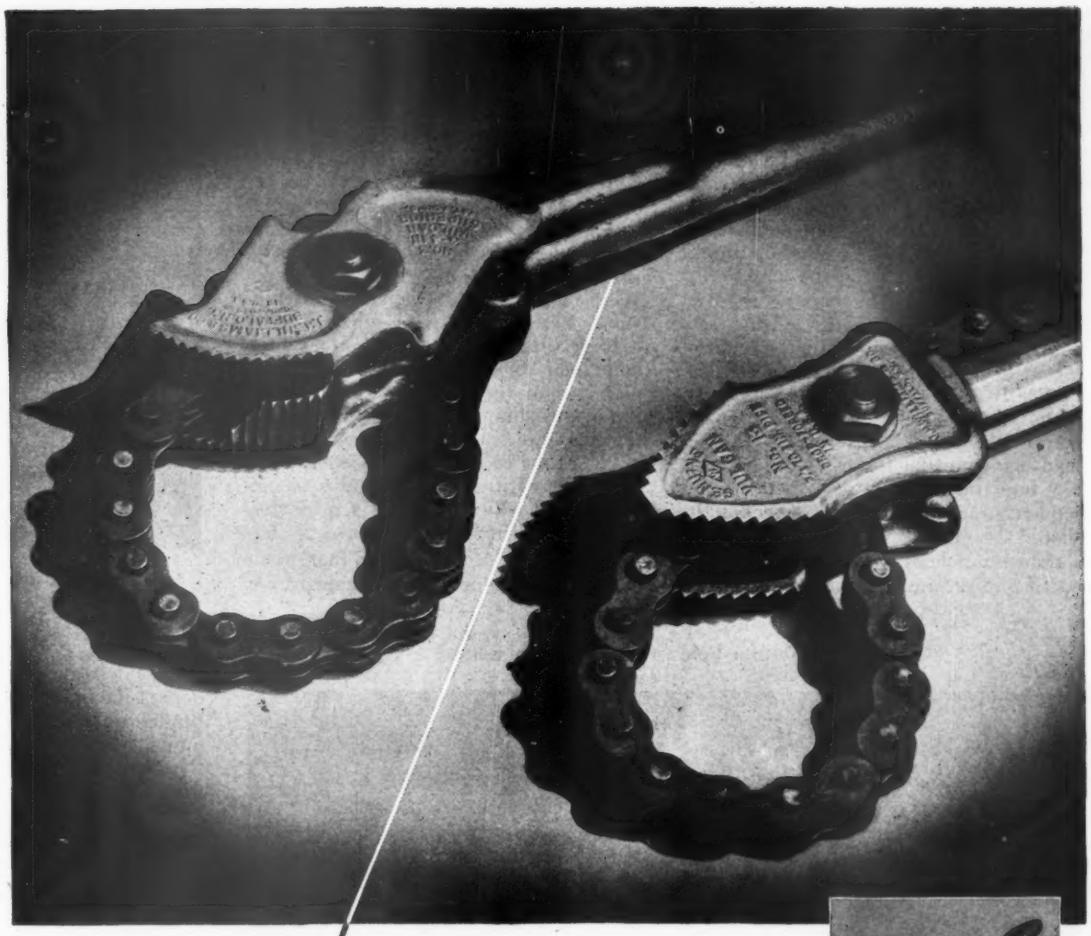
As the inclinometers are not full-hole size, they must be provided with some sort of centering device or they will give erroneous readings. A simple rubber feeler with flexible fingers avoids undue friction, keeps all parts equidistant from the walls of the drill pipe and in general seems to solve this problem very effectively. There are also no doubt other types of apparatus that perform this same function satisfactorily.

DIRECTIONAL single shot and multi-shot instruments are, as the names imply, designed respectively to take one reading or a series of readings. The single shot is ordinarily used while drilling, to take a spot gage at one specific level, whereas the multi shot makes a continuous record of deviation and directional drift during a roundtrip in and out of the hole. In open hole, the single shot may be lowered on a sandline. Inside the drill pipe, a small instrument may be either go-deviled or lowered on a sandline.

One species of single shot consists of a container in which is a movable disk held in a northerly direction by compass needles, used to provide the azimuth or directional indication. The deviation from the perpendicular is derived from a plumb-bob and chart. The record is photographed on a stationary plate, batteries and light bulbs supplying the necessary illumination. No darkroom is required to develop this photograph, as the instrument is equipped with all the facilities for loading, unloading, and developing. A popular type of single shot employs the cross hair and pendulum assembly, already referred to, with a magnetic compass to provide the essential directional data. The magnetic compass is floating and transparent and the photographic device superimposes a record of it on the inclination chart.

Multi-shot or continuous surveying instruments are mostly self-contained and operate automatically at regularly predesignated intervals, both going in and coming out of the hole, so that the coming out readings serve as a check on the going in series. Direction records are developed by a gyroscopic indicator, a magnetic compass, or by orientation of the drill pipe. Inclination records usually are obtained by the plumb-bob crosshair method or some modification thereof, or by a pendant stylus. The electrically operated instruments receive their power from dry cells and a timing mechanism controls the exposures, the face of a synchronized clock being photographed simultaneously on the chart to permit correlation of depth with result. When the instrument is lowered on the drill pipe, depth is obtained by adding the stands of pipe, and when lowered on a wire line, by use of a wire line meter.

There has comparatively recently been developed a non-magnetic drill collar that allows the taking of directional



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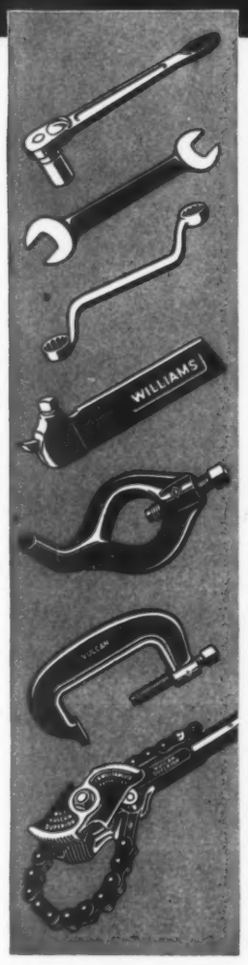


WILLIAMS
DROP-FORGINGS AND DROP-FORGED TOOLS

single shots inside the drill pipe. This eliminates the need of removing the drill string and threading the instrument through a specially designed bit. The non-magnetic collar is placed just above the regular bit and the non-magnetic section carries the directional single shot instrument rigidly and in a position that is parallel to the walls, thus eliminating any error that might be caused by tilting in relation to the axis of the bore.

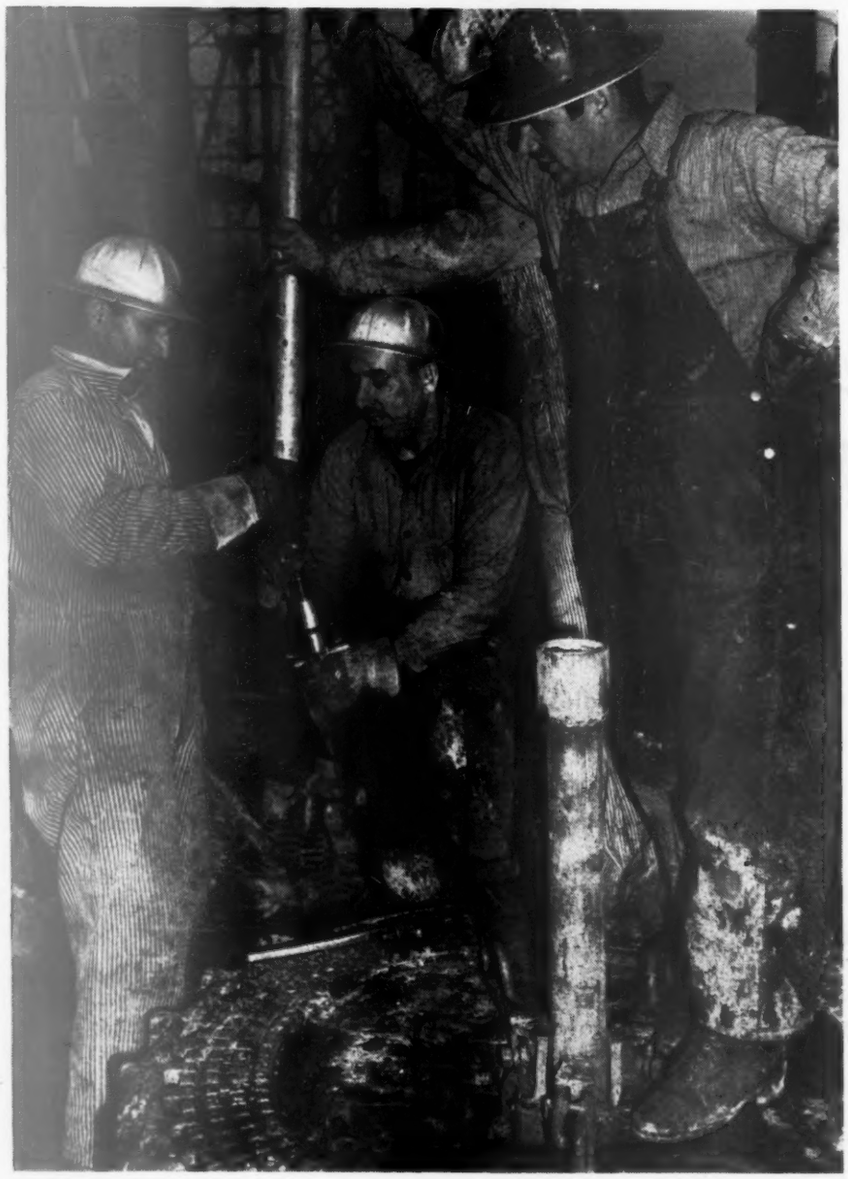
Multi-shot records taken at regular intervals (usually 100 ft.) during the course of directional drilling, are projected horizontally, and sometimes also vertically in north-south and east-west planes, so that progress and trends may be quickly visualized. Not only do these maps indicate the status of the hole at any interval, but they also dictate subsequent procedure. In this connection, it should be emphasized that one of the significant details of operation that is contingent on the inclination and directional surveys is the orientation of the deflecting tools when it becomes necessary to change direction.

These deflecting tools are of three general types, whipstocks, knuckle joints, and spudding bits. The whipstocks may be permanent (used only in cased holes) or removable and there are many modifications of each species. The most commonly used is the removable variety, which can be withdrawn after each deflecting operation. In general the whipstock is merely a wedge-shaped steel casting with a chisel type bottom edge and a heavy collar at the top. The inside diameter of the collar is smaller than the outside diameter of the bit used, so that the latter shoulders against the lower end of the collar when the assembly is lifted. The withdrawal can also be accomplished with the use of a retrieving sub, situated immediately above the bit.

The sub has latches or pins, that, when opened by a go-devil, are engaged by a depression in the collar of the whipstock, thus permitting the latter to be rotated, either when coming out or going into the hole, the latter without danger of prematurely cutting off the shear pin that attaches the whipstock to the bit or the sub. The chisel edge of the whipstock, incidentally, assures its firm anchoring at the bottom of the hole.

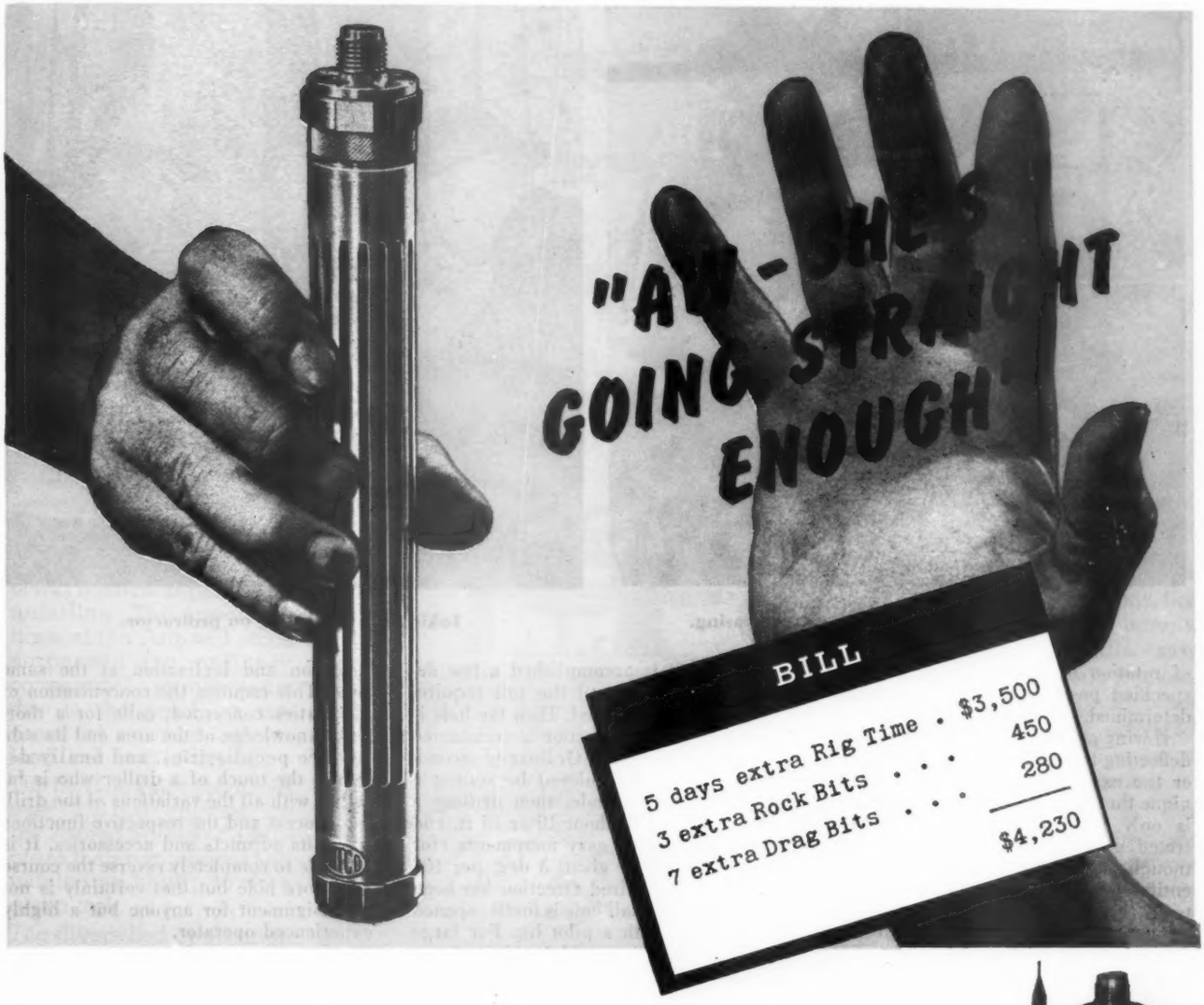
Loading the single shot instrument.

M-M-O bottom hole orienting instrument.



The knuckle is a variation of the ball and socket universal joint, which guides the drill into operation at an angle to the axis of the drill stem at any level where such deflection is decided upon. After a few feet of hole have been drilled, the knuckle joint straightens out and the hole is continued without deviation until further deflection is necessary or the well is completed. The spudding bit is a large shovel-like drill, which is used only in soft and unconsolidated formations, and then just for a few feet to start the hole off in the right direction. It is so constructed that the mud jet, striking its upper face, softens and loosens the material in front of it, and the weight on the bit then guides it in the direction in which it has been oriented.

The orientation of deflecting tools is an exacting process that must be performed by understanding technicians. It is in some instances accomplished by positionally relating the drill stem to every succeeding stand of pipe, and relating the whole to a carefully defined directional index on the derrick floor. The magnetic method of orientation is contrived with the aid of a non-magnetic sub, carrying two small magnets and a small single-shot instrument. In the single-shot, the inclination unit is replaced by a second compass. The relation between the direction of the deflecting tool and the north-attracting magnet is determined at the surface, then they are lowered quickly and a single-shot record is taken when they have reached bottom. This shows the immediate resting position of the deflecting tool. The degree



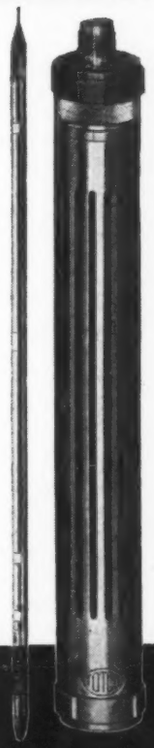
It cost $4,230 to say that!*

"Remember, George, when you said that — said you couldn't be bothered taking Totco readings? And remember I told you then that **not** using a Totco and Controlled Vertical Drilling Methods was going to cost you money? Well, it did — it cost you just about $4,230. How do I figure that? Easy — here's how.

"I made my well, right there, through the same formations you did; just about the same depth, same kind of equipment — you know that. Well, I had 20 days drilling time; you took 25 days. That's 5 days rig time at about 700 bucks a day. Then, I used only 11 bits, while you used 21. That's 10 bits: the 3 rock bits you used to break that bad angle . . . say, $450; 7 drag bits, call it $280. Add 'em up, George . . . it comes out that your well cost you $4,230 too much.

"Now you know why I always use the Totco Recorder and Controlled Vertical Drilling Methods. Been using 'em for years, because with them I drill better wells, drill 'em faster, drill 'em cheaper. Why don't you use them on your next job?"

*Based on actual records in our files.



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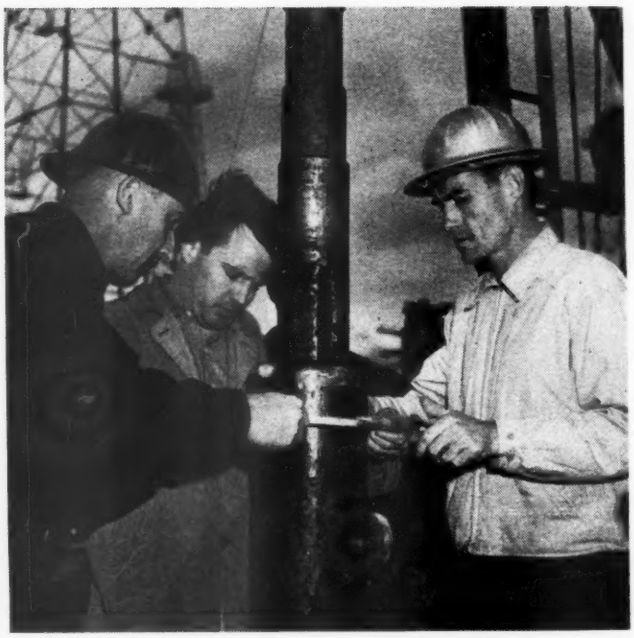
Single shot coming out of protective casing.



Taking initial reading on protractor.

of rotation required to bring it to the specified position can then be quickly determined.

Having oriented the whipstck or other deflecting tool, there remains to the driller the exposition of a particular technique that, like any operational acumen, is only fully developed with concentrated application and experience. Although aided by a great variety of scientific data, very fine equipment and tools, the directional driller reaches the zenith of his potential when he has the feel of the business. It is popularly stated that unpremeditated drift is the result of excessive weight on the bit. It is only natural then that the driller should correlate weight indications and all other data available to him with the subsurface phenomena that are coincidentally observed, and eventually become a specialist in both diagnostic and remedial measures.

It seems to be pretty well established that when by any means a directional trend is started, it usually continues for some time after the initial change in the same direction but, of course, there is no certainty about this. It is well known also that many factors can and do influence directional continuity, for example, the sudden encountering of formations of lesser or greater density or hardness. With all these influences and their effects the experienced driller becomes more and more familiar and he must simultaneously become more understanding of the fundamentals of directional control and their application. At the same time the instruments and tools are subject to constant refinement and improvement so that in every aspect the art is being advanced.

DEFLECTION of the secondary type can be induced by changing the length of the drill collar and the size of the drill collar above the bit and reamer. When a sizeable ultimate deflection is to be contrived, it is accomplished a few degrees at a time until the full requirement has been reached. Then the hole is straightened and direction is maintained toward the objective. Ordinarily secondary deflection is achieved by setting a whipstock in the hole, then drilling a small rathole for about 10 or 15 ft. and continuing this in easy increments (for major deflections, about 3 deg. per 100 ft.) until the desired direction has been attained. The small hole is finally opened to full gage with a pilot bit. For large deflections a removable whipstock or knuckle joint, combined with the right rotary speed and bottom weight are utilized to accomplish the desired result.

Adaptation of ordinary drilling equipment and method is frequently employed successfully to bring about slight directional and inclinational changes. Adjustments of the drill collar, that is with respect to size and weight, control of bit speed, bottom weight, and even manipulation of mud pump speed can all be utilized in controlling the course of the bit. It is apparent that for any application of these operational maneuvers, the driller must be thoroughly familiar with the involved subsurface conditions as well as the techniques of drilling. And regardless of his facility with the implements and processes of a highly scientific business, he must use the specific tools and surveying instruments to be sure of success.

Type of bit used also has an influence on the route traveled through the substrata. It is common practice when decreasing the drift, that is coming back toward the vertical, to change the bit and reduce the bottom weight. With accurate weight indicators now available the control of this factor is much more specific and its effects much more easily determinable.

The problem that develops the most complicated situation is the changing of direction and inclination at the same time. This requires the concentration of all parties concerned, calls for a thorough knowledge of the area and its subsurface peculiarities, and finally demands the touch of a driller who is familiar with all the variations of the drilling process and the respective functions of all its adjuncts and accessories. It is possible to completely reverse the course of a bore hole but that certainly is not an assignment for anyone but a highly experienced operator.

CONTROLLED directional drilling has grown up! It is no longer a special stunt. On the contrary, it is simply adequate operation. Every well may in some degree be called a directional project—even if it goes straight down. Control of the course of the bit is a demand of efficient and effective drilling. Surveying instruments are auxiliary eyes that science has provided so that we can see through hundreds, thousands of feet of solid earth—so that we no longer have to guess. These instruments have been improved and refined in a remarkable way since they were first used.

Deflecting tools and supplementary equipment have been developed to shape the course of the drill to any conceivable inclination and in any conceivable direction. Engineers and technicians in cooperation with the drillers have defined techniques to handle a wide variety of operations, and are conducting constant research to the improvement of these techniques. There seems little doubt that we are now witnessing that particular stage in the progress of the drilling art at which "controlled directional drilling" may simply be called "drilling." The former has some degree of application in all normal drilling procedures and is destined to play an even more important role in the processes of the future. ★ ★ ★

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STAINLESS AND HEAT RESISTING STEELS

By **JOHN S. EWING***, Carnegie-Illinois Steel Corporation

STAINLESS and heat resisting steels have a wide range of uses in the petroleum refining industry. No one type is suitable for all applications but, fortunately, it is not too difficult to make a suitable selection. Operating efficiency, quality of product, and economy are primary design considerations, but with them the items of corrosion resistance, structural strength of the material to be used, and the safety of the whole installation must also be studied. Workability of the steel is an important factor in connection with its fabrication, both in the shop and in the field. All these factors, and many more items as well, must be balanced against the specific problems involved in any individual installation before a definite selection of the steel is made so that the entire installation will be both economical and efficient.

EXCLUSIVE

Generally speaking, the corrosion resistance of chromium alloy steels increases as the percentage of chromium increases, but not as a straight line function. For instance, the 4 to 6 per cent chromium steel has been found highly resistant when mild corrosive conditions exist. As conditions become more severe, however, the next step involves the use of approximately 12 per cent chromium, and with 23 per cent chromium still another increase in corrosion resistance is attained.

Petroleum refining industry finds wide variety of uses for modern-type steels.

Similarly, resistance to oxidation or scaling at elevated temperatures depends primarily upon the chromium content, although the use of varying additions of nickel, and in some cases relatively small percentages of silicon, titanium, and columbium, will increase the ability of the steel to withstand the scaling action of elevated temperatures.

Still tubes, transfer lines, vapor lines, and heat exchanger tubes, however, require high strength at elevated temperatures in addition to resistance to corrosion. The steel used in these applications must also be such that it can be fabricated by welding and ductile enough to form and facilitate the rolling of tube ends into header plates. Further, it must be such as to remain stable under operating conditions. Where extremely severe operating conditions are encountered, steels containing as high as 25 per cent chromium and 20 per cent nickel have been used successfully; usually, however, 18-8 stainless steel, with relatively small additions of molybdenum, titanium, or columbium, will fill the need.

In the average refinery, corrosion is usually caused by sulphur or chlorine and their compounds. This action may be accelerated because of mechanical effects such as turbulence near the end of a tube or in a zone of vaporization or condensation. High velocity of flow or pronounced turbulence act to prevent the formation of the protective coating normally formed on the steel surface, or to eliminate any film already formed, thus exposing unprotected steel to corrosive attack. This condition has not been entirely brought under control, but modern design and the uniformly high quality of stainless steels now available are rapidly solving the problem.

Corrosion conditions may vary to an extreme degree between the two ends of a petroleum refining process because of the differences in temperature. At the hot end the temperature and pressure are usually such as to eliminate the presence of liquid water. As a result, the active corrosive agent is usually sulphur, a simple sulphur compound or possibly O_2. The presence of liquid water at the cold end of the process, however, complicates the corrosion problem, for organic acids as well as sulphuric, sulphurous, or hydrochloric acid may be present in strong enough concentrations to attack the steel. Entrained phosphoric or sulphuric acid may be encountered in polymerization plants. Consequently, steels that are entirely satisfactory for use in hot end applications may not be suitable for use at the cold end. Usually, however, steels that will withstand cold end conditions are suitable for use in hot end applications from a technical point of view. Economics usually will dictate the final choice.

As no general recommendations can be made, the various applications and types of corrosion- and heat-resisting steels will be discussed briefly as follows:

● **Bubble caps.** Because of their light weight, stainless steel bubble caps are coming into wide use in natural gasoline plants handling sour gases, in absorbers

*John S. Ewing is an engineer in the stainless steel division of Carnegie-Illinois Steel Corporation, a subsidiary of United States Steel Corporation.

Stainless steel bubble trays are light and easily placed in position.

AT LOS ANGELES

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MIDWEST PIPE FABRICATING PLANTS

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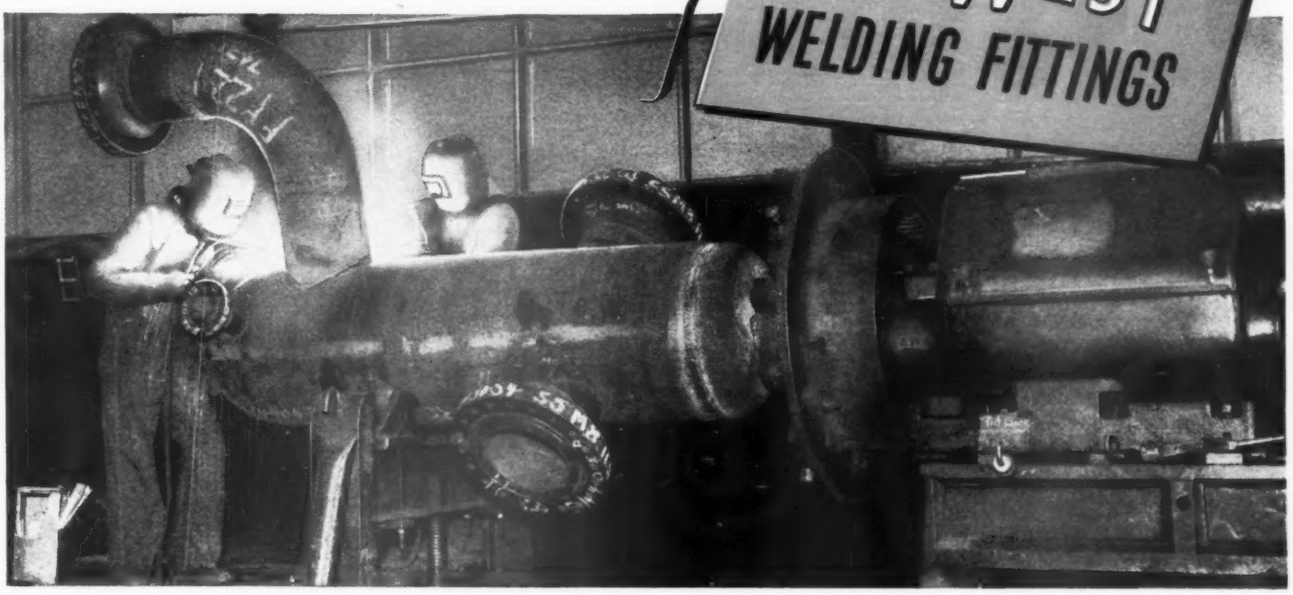
on the HIGH QUALITY of MIDWEST WELDING FITTINGS



Four modern Midwest pipe fabricating plants supply piping for all purposes and pressures to a great variety of industries from coast to coast. These Midwest plants are large users of Midwest Welding Fittings. This regular everyday use of these fittings in fabricating both simple and complex piping subassemblies provides an accurate and continuous check of their quality . . . of correct dimensions . . . of uniformity . . . of accurate angularity, etc.

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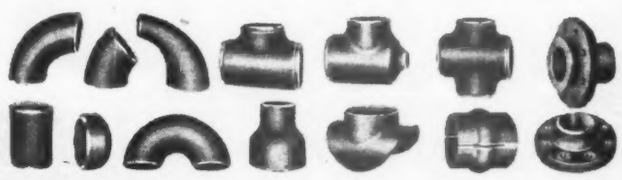
MIDWEST WELDING FITTINGS IMPROVE DESIGN AND REDUCE PIPING COSTS



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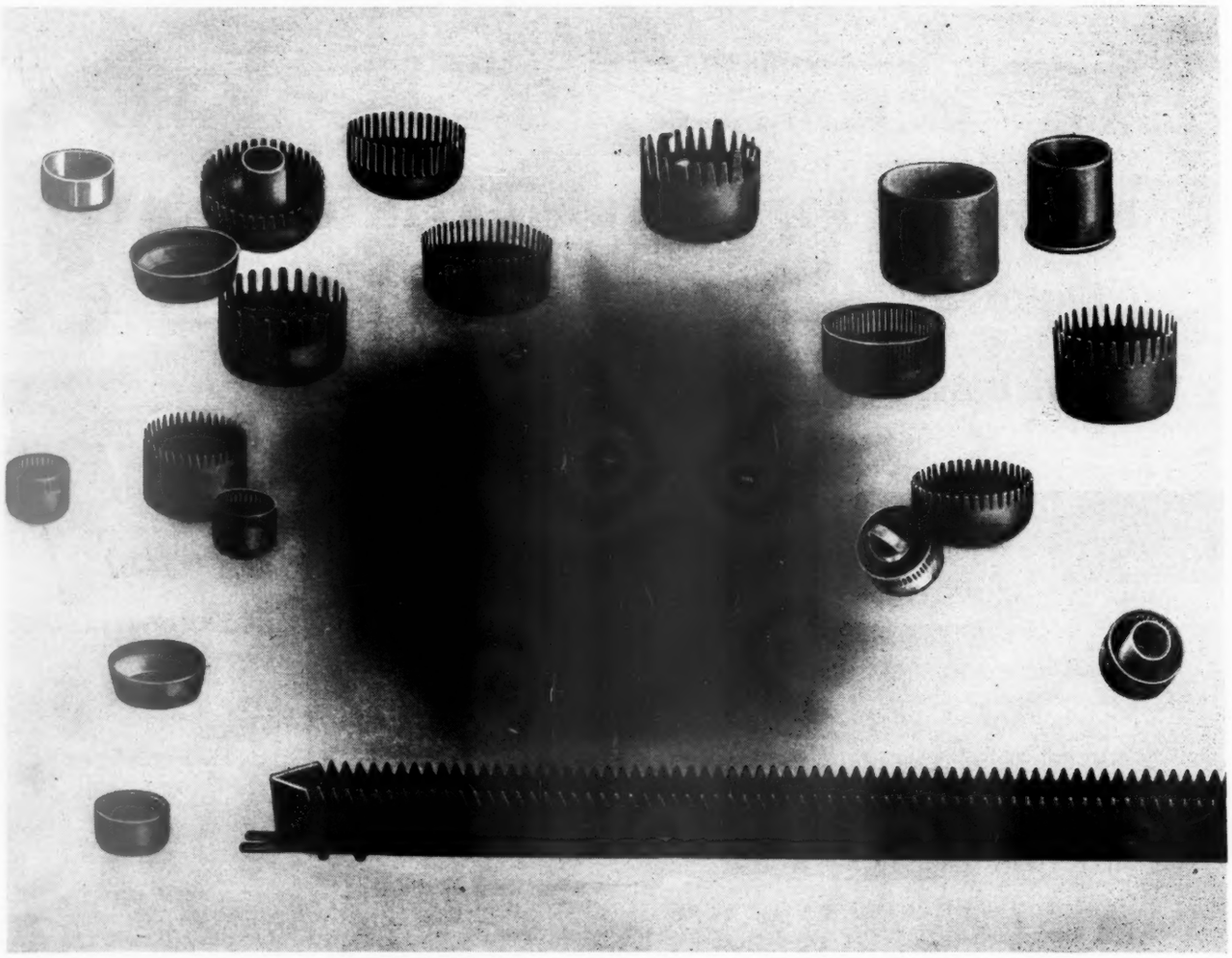


Stainless steel bubble caps are easily fabricated into any desired size or shape.

and stabilizers, and in crude, vacuum and pressure distillate (cracking) bubble towers. They are easily fabricated because of the tough and ductile character of the metal and sharper fractionation is more easily attained because there is little or no danger of towers being operated with caps having broken result.

Stainless steel bubble caps are not normally susceptible to coking through corrosive action. Consequently, towers are on stream longer, down time for cleaning is shorter, and less labor is involved. Inasmuch as towers equipped with stainless bubble caps are free from fouling, pressure drop remains constant, and better production and better operation result.

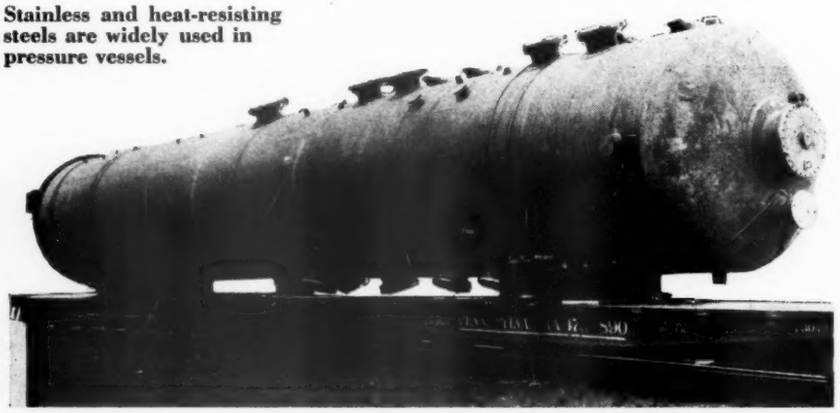
More caps per tray, or a smaller tray containing the same number of caps, can be installed when stainless steel is used for the bubble caps. Being extremely thin and easily punched, stainless steel bubble caps can be made with more teeth, which aids in effecting a more intimate mixture of the vapor and the liquid on the tray. Most caps are now being made from 12 per cent chromium, 17 per cent chromium, of 18 per cent chromium-8 per cent nickel types of stainless steel.

● **Bubble trays.** The experience gained in other fields has made it possible to fabricate stainless steel bubble trays economically and they can be used for most types of high temperature service instead of being restricted for use in only those applications where severe corrosive conditions are encountered. Good design holds weight to a minimum while the corrosion resistance of the metal minimizes attack and its toughness holds breakage to minimum, which is sufficiently low to not interfere with the economic operation of the unit.

When stainless steel is used for bubble tray construction, experience shows that the towers can be put on stream or cooled down for clean out and inspection more quickly. Being lighter in weight, stainless steel trays have less heat capacity than cast-iron trays, thus making it possible to change temperatures without the delay normally attendant upon "circulation" to adjust temperatures.

Hot end applications, where temperatures range from 400 to 1000°F., may ordinarily be filled with 12 per cent chromium stainless steel, which has sufficient corrosion resistance to meet the conditions encountered where liquid

Stainless and heat-resisting steels are widely used in pressure vessels.



KARBATE
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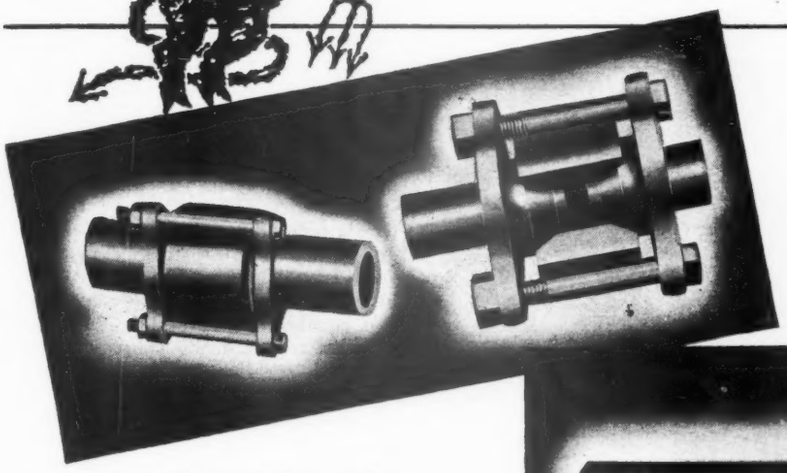
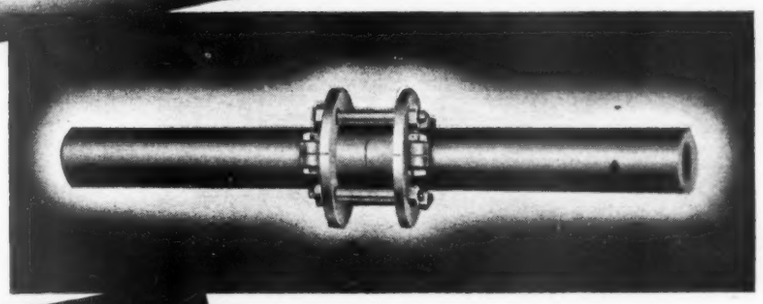
EQUIPMENT CONNECTIONS



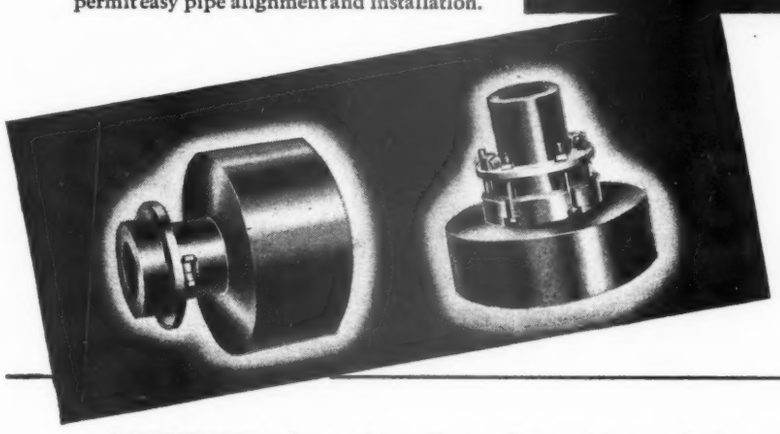
Type FC Flexible Coupling

Permits movement in any direction to protect "Karbate" piping from effects of vibration, misalignment, and differential expansion. Easily installed or dismantled on the job. Simplifies final pipe-length adjustment between pieces of equipment. Used with "Karbate" preassembled standard nipples and fittings, pipe may be cut to length and rapidly installed in the field.



Type V Flanged Connection

Thick, small-diameter collars provide sturdy construction. These can be used with companion flanges of almost any design or material. The separate cast-iron split flanges permit easy pipe alignment and installation.



Type V Nozzle
Type SC Slotted Coupler

Recommended for connections on "Karbate" tanks, towers, heat exchangers, and similar equipment. Generally installed at our factory—not particularly suitable for field installation. The Slotted Coupler is of more compact construction than the Type V Nozzle, but the choice of connection depends upon requirements of each job.

STRENGTH and ease of installation distinguish four improved "Karbate" chemically resistant equipment connections that are doing a first-rate job in many kinds of service.

. Like the many "Karbate" specialty products used for **storage, conveying, handling,** and **processing** of corrosive liquids and gases, these connections are not only strong, but have high resistance to mechanical and thermal shock and to the action of most acids (notably hydrofluoric), alkalies, and other corrosive chemicals.

The designs of these connections are the result of years of experience of National Carbon Company, Inc., in furnishing "Karbate" impervious carbon or graphite equipment to the chemical, process, and other industries.

• • •

For additional information about "Karbate" equipment connections, write to our nearest Division Office for Catalog Section M-8805.

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water is absent. Strip tests, however, are recommended for cold end applications to make sure that the steel selected will have sufficient corrosion resistance to meet the specific conditions and at the same time possess the other properties necessary.

All types of stainless steel can be fabricated with standard equipment and as a result, maximum efficiency in both mechanical and chemical engineering design can readily be attained. Thin material, tough and ductile, facilitates fabrication and design, and stainless steel has proved to be a highly useful metal for a great number of petroleum industry applications.

● **Liners.** Economical protection against corrosion in reaction chambers, flash towers, evaporators, coking drums, vacuum towers, bubble towers, and heat exchangers may be obtained by applying thin sheets or strips of stainless steel to the inner surfaces of the units, the material being applied either in the shop or in the field as may be most suitable. Under ordinary conditions in hot end service, 12 per cent chromium steel will provide adequate protection to the equipment, but where exceptionally severe conditions exist, the 18-8 or 18-8 Mo types should be used.

Stainless steel linings serve to insulate the shells to some extent and thus aid in preventing distortion or cracking when the vessels are being cooled rapidly. This action serves to cut down the time off stream and in many cases is, in itself, a sufficient reason for the application of stainless steel liners.

● **Valves.** More and more stainless and heat-resisting steel is being used for refinery valves and trim. Martensitic stainless steel, such as the 12 per cent chromium type, which can be hardened by heat treatment, finds extensive use in hot end applications where corrosion conditions are not too severe. Many operators, however, prefer to use the same type of equipment throughout the plant, and as a result, must use a steel that will stand up under the attack of cold end corrosive products. For such use, the austenitic type 18-8 chromium-nickel steels are giving very satisfactory results in valve trim. The long life of such valves in hot end service and the convenience and economy of maintaining a smaller stock of replacements frequently justifies the somewhat higher price of the valves made of the more corrosion-resistant steel.

● **Pumps.** Pump rods are now being made of 18-8 stainless steel because of its toughness and resistance to corrosion. Heat-treated 12 per cent chromium steel finds a useful place as impeller shafts for centrifugal pumps because of its desirable combination of hardness and satisfactory corrosion resistance. Plungers in hot oil pumps handling corrosive stocks have been made successfully of both 5 per cent chromium-molybdenum steel and of 18-8 stainless steel, the choice depending upon the degree of corrosive action of the stock being pumped. In many instances it has been found economical to make the entire pump body of stainless steel.

● **Weld overlays.** Exposed steel surfaces can be protected economically by the application of weld overlays, using 18-8 or 25-20 stainless steel welding rods. Such overlays not only guard the base metal against corrosive attack, but also protect it against erosion or washing action that may give trouble with the softer, less corrosion-resistant metals.

Other effective and economical applications of weld overlays include building up corroded, eroded, or wire-cut bodies of control or flow valves; facing flanges or building up the bonnets of valves; and lining spools, vapor line ends, junction boxes, headers, plugs, and return bends. Hot oil pumps have been successfully built up by welding, as have plugs and bodies of plug cocks. Check valve bodies, and application inside the stainless trim on gate valves also afford other opportunities to make use of the economies that are possible through the use of stainless steel weld overlays.

● **Miscellaneous hot end applications.** It is impossible in a short article of this nature to list all the important applica-

Men line existing refining equipment with stainless steel strip to increase life of equipment.

Stainless and heat-resisting steels are used in a wide variety of piping in the petroleum industry.

tions of corrosion- and heat-resisting steels. The principal applications have been outlined above, but there are a host of other important, yet relatively minor, applications of stainless steel around the hot end of any refinery. For example, the 12 per cent chromium and 18-8 stainless steels are now being used for liners in towers, nozzles, gaskets, and orifice plates. Thermocouple wells and ball floats fabricated from 18-8 stainless steel have given good results in service. Tube sheets, baffles, supports and spacers for heat exchangers bundles in many refineries are now being made from 5 per cent chromium steel, 12 per cent chromium steel, and 18-8 stainless steel according to the specific needs. When corrosive stocks have to be handled through heat exchangers, operators report good service from 5 per cent chromium-molybdenum and 18-8 stainless steel tubes. Other miscellaneous applications include tray support angles, rain decks and baffles in bubble towers and evaporators.

Stainless and heat-resisting steels can be applied to good advantage in connection with furnace dampers, high temperature air preheaters, and gas recirculating systems, the type of steel to be used depending upon the conditions involved, including both temperature and degree of corrosive action possible.

● **Cold end applications.** Under varying conditions, all the stainless and heat-resisting steels, including the 5 per cent chromium-molybdenum type, have given economical service in cold end refinery applications. Straight chromium steels, however, must be used with discretion when there is the possibility of hydrochloric acid being produced by the hydrolysis of salts such as magnesium chloride during the thermal treatment of the stock, or when SO_2 or SO_3 is present. An economic study of the whole problem should always be made, for the economy possible when the 5 per cent chromium-molybdenum or the 12 or 17 per cent straight chromium steels can be used is worth gaining, if possible. These steels have demonstrated their value in many instances where cold end corrosive action was not too severe.

Type 316 stainless steel, which contains approximately 2 to 3 per cent of molybdenum in addition to 18 per cent chromium and 8 per cent nickel, has given complete satisfaction in cold end service. This type of stainless steel shows a corrosion resistance at all times equal to that of the usual 18-8 stainless steel, and where acids such as dilute hydrochloric, sulphuric, sulphurous, wet hydrogen sulphide, or phosphoric, as well as a wide group of the organic acids, are present, its greater corrosion resistance proves valuable. Trial installations have been highly successful and consequently the use of 18-8 Mo type of stainless steel is increasing rapidly in refinery applications.

Vacuum and pressure relief valves on storage tanks must function smoothly at all times for best results. Use of 18-8 stainless steel in these valves and seats will assure a smooth, dense surface and a perfect fit between the valve disk and the seat, thus making smooth operation of these important valves more certain.

No single type of stainless steel should be considered as a cure-all for all the corrosion or high temperature problems encountered in refinery operation. Each of the several types and grades now available has a place and the application of the right grade to the particular situation is a technical problem that must be considered from all angles. The final answer lies in attaining an economic balance between cost and operational efficiency. Technical advice should be sought from refinery chemists and operators in conjunction with the experience of the engineers and metallurgists whose services are offered by the companies making stainless steel. Their experience can safely be relied upon, for they have been confronted by corrosion and oxidation problems in many different guises and what may appear to be a major problem may often be solved by utilizing the information gained in solving a similar problem that was not so important in another plant, yet which had to be solved for fully satisfactory results of the installation as a whole. Information of that kind cannot be assembled into standard recommendations as there are so many complicating factors, yet it is freely available upon request.

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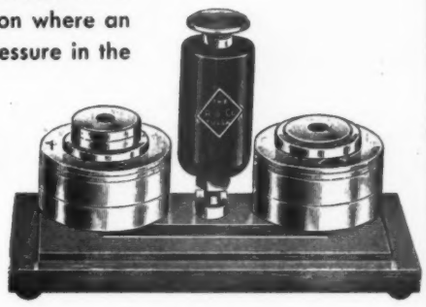

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PRESSURE MAINTENANCE BY WATER INJECTION, MIDWAY FIELD, ARKANSAS†

By **WILLIAM L. HORNER,*** Barnsdall Oil Company

CONSIDERABLE interest is manifested toward poolwide application of pressure maintenance by water injection as a means of adding to the recovery from oil and gas fields. Data obtained at Midway disclose conclusive results, and confirm indications which were outlined before a meeting of the Division of Production of the Institute at Chicago, November 11, 1943.[1] Since that date pressure, production, and cost records have been accumulated—which may be deemed of timely importance. The earlier publication referred to showed that injection into one well, located at the edge of a pool, 1800 acres in area caused a marked decrease in the rate of pressure decline in the pool. Since then injection has been maintained in 4 wells, with the result that reservoir pressures have risen —although during the same period allowables and withdrawal rates have been increased substantially.

● **Pool conditions.** The pool contains 41 producing wells that were completed between January, 1942, and December, 1943. Eight wells, initially of low productivity, are equipped for artificial lift. A productive area of approximately 1800 acres is shown to be located on an anticlinal structure (Fig. 1), and has been found by several independent methods to contain approximately 150,000,000 bbl. to 160,000,000 bbl. of stock-tank oil in place. There is no gas cap, the oil being uniformly saturated with gas at a pressure of 2528 lb. per sq. in. gage, a pressure that may be compared with the pool average of 2674 lb. per sq. in. on July 1 and 2920 lb. per sq. in. at discovery.

The original limits of the pool appear to be defined roughly by contact of the top of the porosity with the datum of 6225 ft. below sea level. In several instances the water-oil contact appears to have been higher, and in some cases lower. The estimate of about 160,000,000 bbl. of stock-tank oil originally in place has been made on a basis of porosity and acre-feet of formation. This value is in close agreement with the value determined by W. A. Bruce in a summary published of the results of his analysis of the pool-performance history.[2] The position of the oil with respect to the water underlying the pool is shown diagrammatically by a cross-section drawn north and south across the center of the pool (Fig. 2). Logs of wells drilled through the oil column indicate that the formation is generally permeable and water-bearing at all points below the oil-water contact throughout the pool. External energy for maintenance of pressure in the pool is believed to be transmitted to the pool primarily through the underlying water. Poolwide contact of the water table with the oil contained in the reservoir appears to facilitate communication of pressure throughout the pool.

● **Pressure-production history.** On January 14, 1942, the initial reservoir pressure for the pool was determined to be 2920 lb. per sq. in. at 6050 ft. below sea level, and by May 25, 1943, had fallen 261 lb. per sq. in. to a value of 2659 lb. per sq. in. The reservoir oil has a bubble-point pressure of 2528 lb. per sq. in. gage, and a compressibility of 15.0 bbl. per million bbl. per lb. per sq. in. pressure at reservoir conditions.

Factual data published by the Arkansas Oil and Gas Commission[3] state that, for the 3 months' period ending May 25, 1943: "The greatest decrease in pressure among the water-driven oil fields was experienced at Midway with a drop in pressure of 0.56 lb. per sq. in. daily." During that 3 months' period average production of oil was approximately 5600 bbl. per day. Injection was begun April 19, 1943, and the record shows influence of injection on the pressure-production history (Fig. 3). Data published by the commission (July 1945) show that, for the first 6 months of 1945, reservoir pressures increased 0.09 lb. per sq. in. per day, whereas oil production had been raised to an average of more than 6900 bbl. per day. Constant allowables were granted for an extended period. This fact aided greatly in interpreting results of injection. On February 1 the daily base allowable per well was increased from 175 bbl. per day to 200 bbl. per day. For the pool, the average oil-production rate during August, 1945, exceeded 7500 bbl. per day.

In addition to the oil recovered, liquids extracted by the gasoline plant averaged 23,700 gal. daily during the same month. Design and operation of the plant are facilitated by the richness of the gas, steady allowables, and constant gas-oil ratio.

● **Distribution of pressure.** With few exceptions since injection began, reservoir pressures have been measured monthly on one-third of the wells in the pool. The pressures of no individual wells appear abnormally high as a result of injection (Table 1). An examination of all the pressure data since injection started discloses a transient effect on producing wells around injection wells. During the first 30 to 60 days after injection begins or has been increased markedly, reservoir pressures measured in the offset wells increase at rates above the pool average, and thereafter the pressures observed return to a position in line with the remainder of the wells. Wells offsetting injection wells likewise are noticed to be only average producers of water. In August, 1945, oil wells nearest input wells No. 1, 2, 3, and 4 produced (respectively) the following percentages of water: 0.3, 6.0, 2.8, and 2.0. During the same period it is estimated the pool production averaged 12 per cent water.

● **Probable pressure-production history without injection.** The oil-production rate during August, 1945, averaged over 7500 bbl. daily. Total reservoir withdrawals, including shrinkage and 1000 bbl. of salt water, totaled 10,000 bbl. per day. Injection of at least 8000 bbl. per day appears to be required to maintain pressures at present levels. Therefore, the rate of natural water drive has diminished to approximately 2000 bbl. per day. On that assumption it can be computed that pressures could be maintained by restricting the rate of oil production to around 1500 bbl. per day. It is believed, however, that, in the absence of injection, a moderate degree of pressure decline would be tolerated by the state regulatory body, and a pool allowable of 3500 bbl. to 4000 bbl. per day could be expected.

● **Economics.** The total operating expenses for the combined pressure-maintenance and salt-water disposal project have declined rather steadily for the past 20 months, and averaged $70 per day for the 3 months ending September 1, 1945. Thus it may be inferred that the additional rate of recovery is obtained economically.

Evidence of the limited amount of natural water drive tends to confirm previous estimates[1] that, through injection, an additional 35,000,000 bbl. of oil could be produced to economic limit. The anticipated increase in ultimate yield may be compared with the costs for installing pressure-maintenance and salt-water-disposal facilities. These total less than one-tenth of the aggregate cost of dis-

†Presented before American Petroleum Institute, Chicago, Illinois, November 15, 1945.

*William L. Horner has been with Barnsdall Oil Company, Tulsa, Oklahoma, since January 1, 1943, as manager of secondary recovery department and assistant vice-president, Barnsdall Research Corporation. He is grantee of patents on earth exploration and core analysis and has had numerous technical papers published. Horner has degrees in petroleum engineering and petroleum geology from University of Pittsburgh. He was with Core Laboratories, Inc., Dallas and Houston, Texas, as director and vice-president in direct charge of operations; with Forest Oil Company, Bradford, Pennsylvania, and Nowata, Oklahoma, as assistant to chief engineer, and with Humble Oil and Refining Company, Houston, as production research engineer.

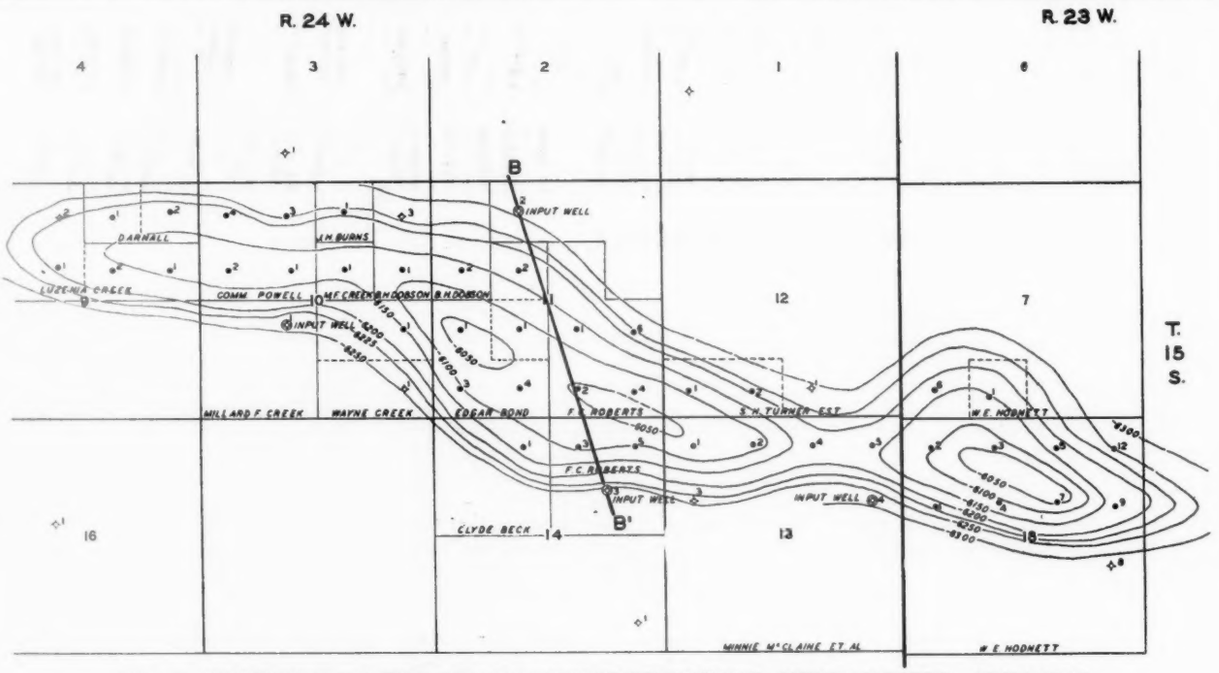

FIG. 1. CONTOURS ON TOP OF SMACKOVER LIMESTONE, MIDWAY FIELD, ARKANSAS.

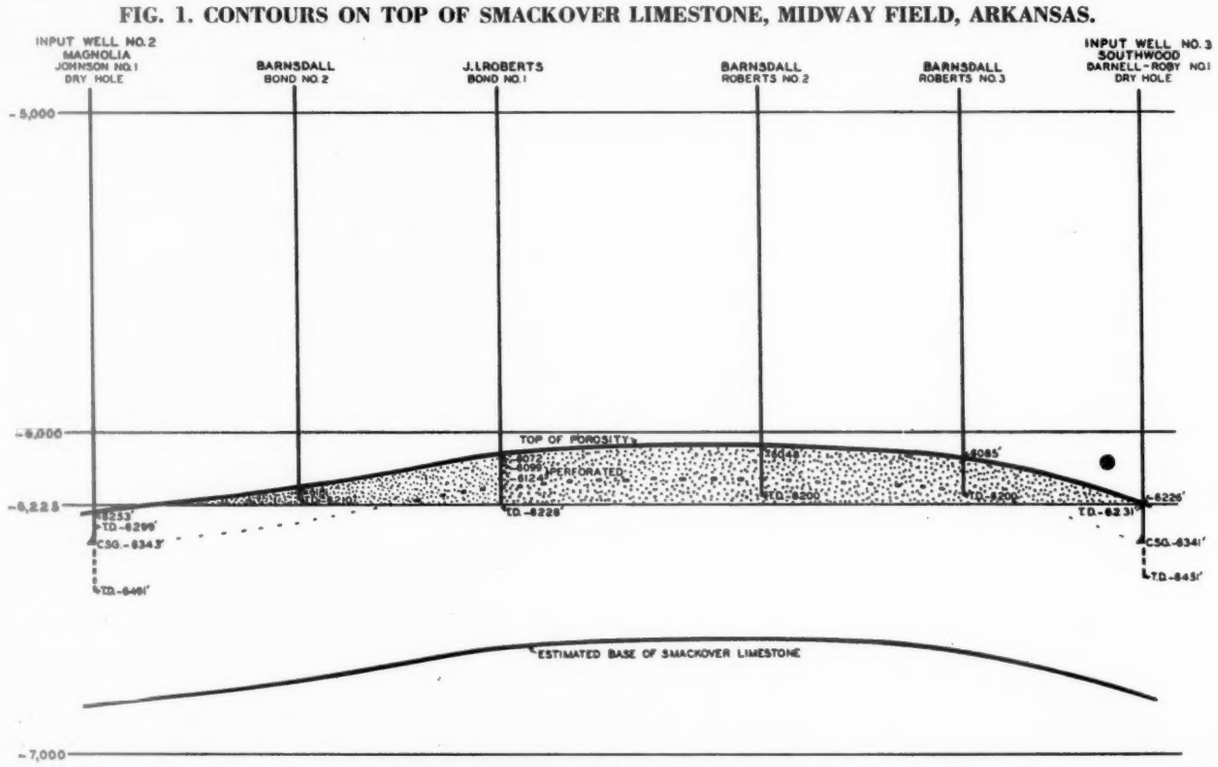

FIG. 2. NORTH-SOUTH CROSS SECTION.

covery and development of the pool.

A third advantage gained by maintaining pressures is realized in reduction of requirements for artificial lifting of oil from producing wells. In addition to the benefits obtained from having higher pressures available to aid flowing, experience at Midway has disclosed that productivity indices of individual "clean" oil wells do not decline with time nor with accumulated production, provided the flowing bottom-hole pressures remain near or above the bubble-point pressure of the reservoir oil.

However, steady decline has been plotted from data on productivity-index measurements for some other wells in the pool that are required to operate with bottom-hole pressures considerably less than the bubble-point pressure (Fig. 4). The behavior of productivity indices of these wells is interpreted as being in line with accepted principles and theories. The productive formation at Midway is a porous limestone largely soluble in hydrochloric acid. In order to maintain production rates, it has been possible to employ new acidizing techniques to raise to a maximum the productivity-index values for 7 wells whose flowing life would have been shortened.

● **Injection facilities. To expedite:** An operating agreement for the project alone was drafted rather than unitization for the entire pool. Because only equities and responsibilities pertaining to the project were involved, the operators decided promptly. The agreement between the 6 operators in the field was made and entered into July 20, 1943. Approval was granted by the commission, which is empowered in such matters by

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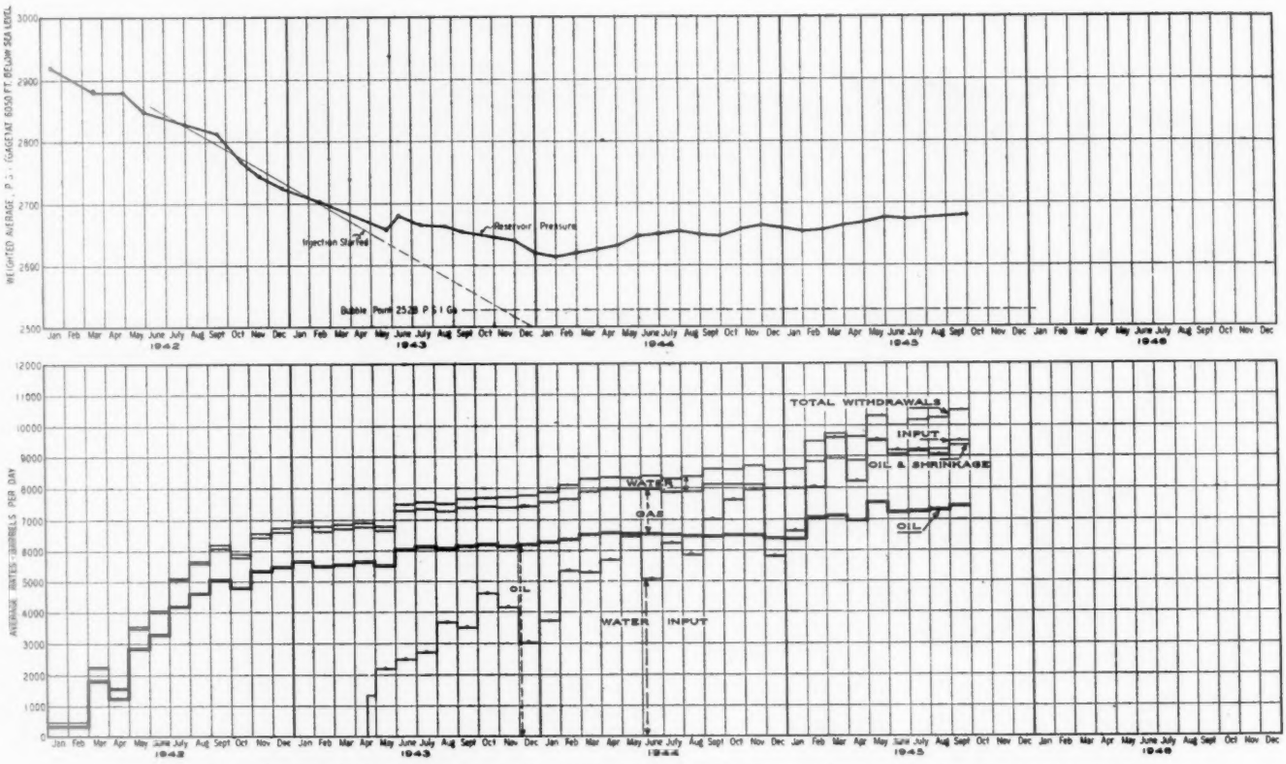


FIG. 3. PRESSURE, PRODUCTION, AND INJECTION DATA, MIDWAY FIELD, ARKANSAS.

a state law.[4] In the provisions of the agreement, the operator of the project "never shall be held to be liable for any results that may occur to the producing formation or any part thereof because of the operation of the system." Each party to the contract shares investment costs and expenses in proportion to the percentage of reserves computed to be recoverable from under each productive tract. Except to maintain pressure and dispose of salt water, production of oil from the individual leases and wells is carried on independently of the joint agreement.

In addition to an agreement between the operators, permission was obtained from the several hundred owners of mineral and royalty interests in oil and gas leases covering lands producing, and also containing, injection wells.

The contract listed the following principal items:

1. Distribution lines (steel pipe, cement-lined) ..... $ 19,585.00
2. 4 input wells (converted from dry holes) 103,151.05
3. Water supply and pressure plant (centrally located plant) 23,960.00
4. Salt-water gathering lines (7.4 miles of cement-asbestos pipe line) .. 61.688.06

The facilities described in the contract were installed. Due to the small capacity of fresh-water wells, it has been necessary to operate 6 individual wells that have an average capacity of less than 2000 bbl. per day each. The fresh-water-supply wells are situated within the field, and are spaced over a distance of approximately 3 miles. All of the water produced from these wells, as well as the salt water gathered from several tank batteries, is kept out of contact with air. At a central point in the field the fresh-water and salt-water gathering lines are led separately to 2 low-form 500-bbl. standard steel tanks.

Oil gathering on the surface of the water in the tanks is skimmed by overflow, and solids settling out during the 2-hr. retention period are periodically removed. A blanket of gas at a pressure of 1 oz. is maintained on the surface so as to exclude atmospheric oxygen. Two pumps driven by gas engines distribute

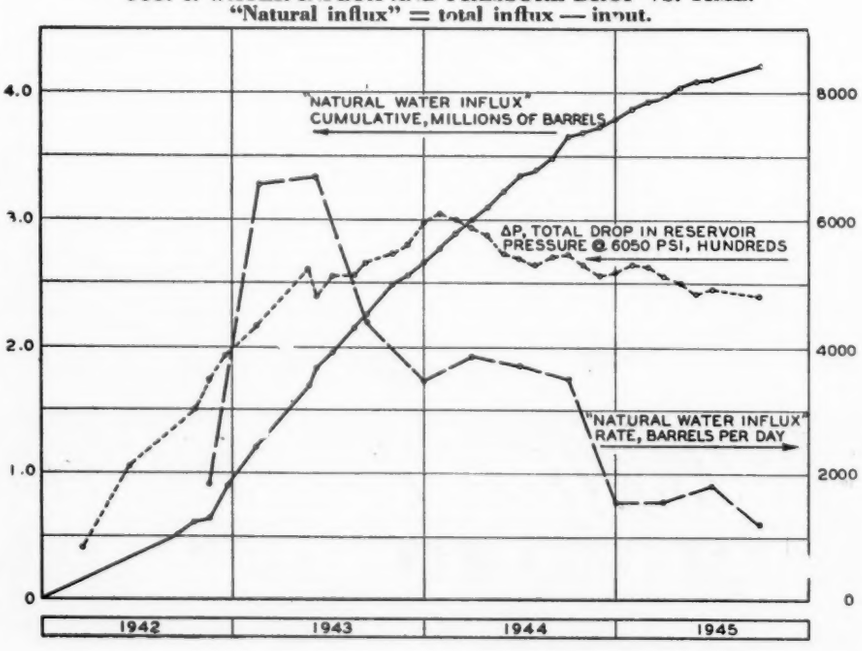
TABLE 1. Reservoir-pressure distribution, Midway field, Arkansas.

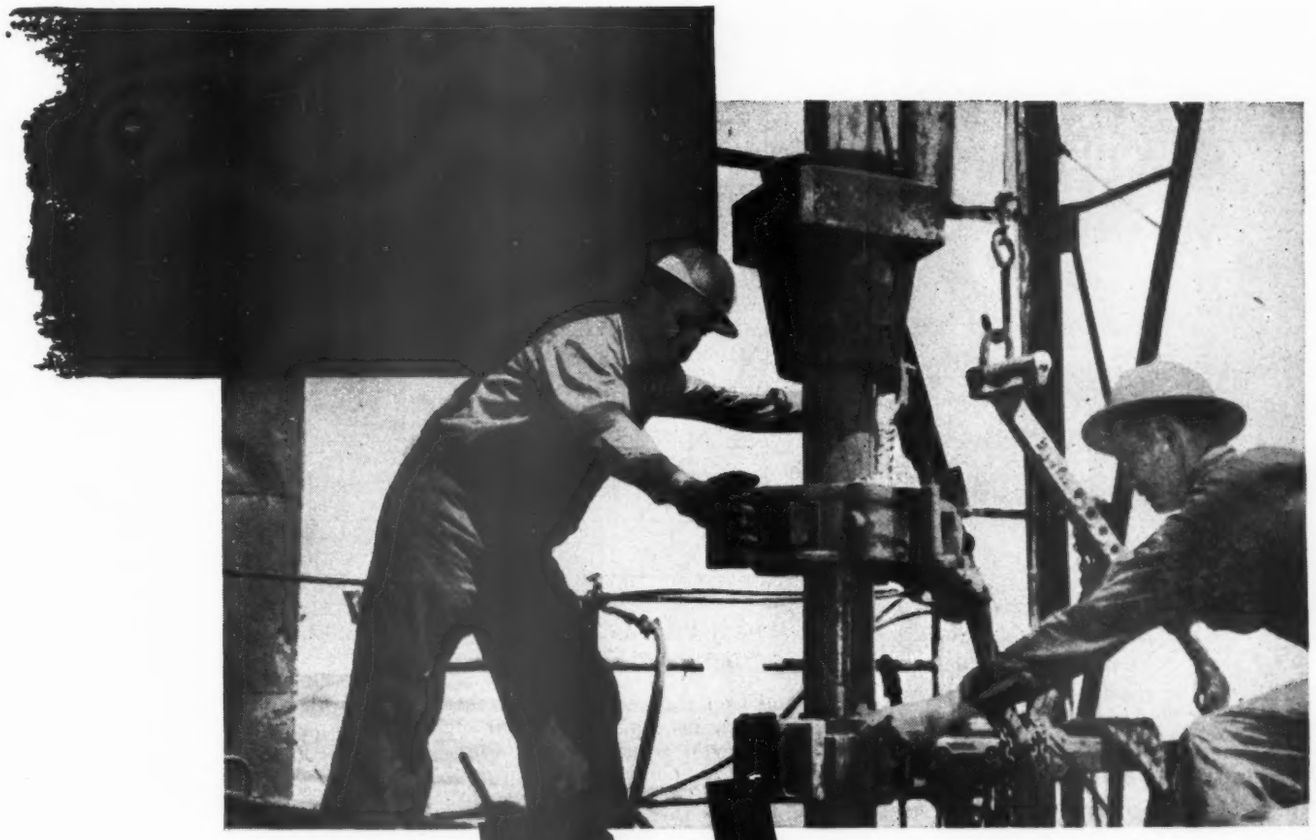
Pressure (lb. per sq. in.) at 6050 ft. below sea level

Well	April 1, 1944*	Oct. 1, 1945
Edgar Bond 1	2621	2694
Edgar Bond 3	2619	2694
M. F. Creek 1	2629	2690
Charles McClaine 1	2608	2687
Charles McClaine 2	2595	2685
Charles McClaine 5	2653	2671
Community Powell 1	2634	2665
F. C. Roberts 3	2617	2687
Roberts' Edgar Bond 1	2621	2686
W. E. Hodnett 3	2655	2686
W. E. Hodnett 7	2680	2690

*Arkansas Oil and Gas Commission Factual Data No. 36, April 26, 1944.

FIG. 4. WATER INFLUX AND PRESSURE DROP VS. TIME.
"Natural influx" = total influx — input.





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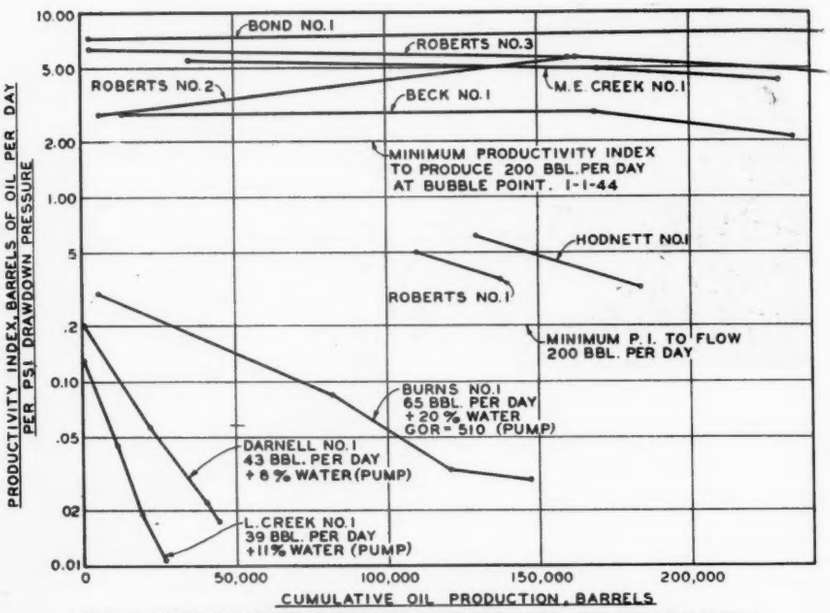

FIG. 5. PRODUCTIVITY INDEX INFLUENCED BY DRAWDOWN.
Assumed 2000 lb. per sq. in. drawdown on wells pumped.

the water from this central point to the 4 injection wells. Although several of the wells would require less pressure for injection, the pumps are regulated to discharge at a pressure of approximately 450 lb. per sq. in. in order to simplify manifolding. It is interesting to observe that this procedure raises power requirements to a water horsepower of 68. In effect, only about 50 hp. is applied to the water injected after it leaves the central gathering tanks.

In general, a uniform procedure was followed for converting the 4 edge dry holes to injection wells. In each instance (Table 2) casing was set at a point at least 115 ft. below the assumed oil-water contact, and approximately 130 ft. of formation remained exposed below the casing shoe. After the drilling mud had been replaced with water, the hole was enlarged 1/16 in. in radius with a rotary wall scraper, and backflow was induced. After a preliminary injection test, 15 per cent acid was introduced in amounts that ranged up to 16,000 gal. per well—immediately followed by injection of water. The first well was treated initially with 7000 gal. It was later acidized with an additional 10,000 gal. to increase its injectivity. This permitted the well to take water at pressures and rates comparable to wells No. 2 and 4. By September 1, 1945, a total volume in excess of 5,000,000 bbl. of water had been injected, more than 1,000,000 bbl. to each of the input wells; and the intake capacities of the wells have remained practically at the original levels.

The fresh water is of potable quality. The brine produced with the oil contains approximately 26 per cent salts. Samples of each water, exposed to the air, develop turbidity within a few minutes. However, samples of the waters taken from injection lines remain clear indefinitely if collected under gas.

● **Applying the method to other pools.** The use of water injection to raise and maintain pressures in entire oil and gas pools is notably beyond the experimental stage. Currently there are almost 20 pools in the Mid-Continent and Gulf Coast[5] areas where expenditures have begun for plans and projects of the type devised for Midway. Several of the prin-

TABLE 2. Injection-well data, Midway field, Arkansas.

	No. 1	No. 2	No. 3	No. 4	
Completion					
Total depth (derrick floor), ft.	6,765	6,778	6,720	6,742	
Total depth (below sea level), ft.	6,490	6,491	6,451	6,477	
Casing sizes (in inches) at depth below sea level, ft.	5½; 6,343	6; 6,343	6; 6,341	5½; 6,354	
Top of porosity (below sea level), ft.	6,230	6,250	6,225	6,264	
Interval from assumed level of 6225 ft. below sea level to casing shoe, ft.	118	118	116	129	
Formation exposed below casing shoe, ft.	147	148	110	123	
Operation, initial					
Date injection started	4/19/43	1/5/44	3/24/44	10/24/43	
Estimated reservoir pressure in nearest well	2,630	2,603	2,610	2,675	
Estimated reservoir pressure in input well	2,636	2,606	2,608	2,689	
Initial injectivity, bbl. of water per day per lb. per sq. in. pressure	3.6*-6.2	7.2	Over 50	7.4	
Operation, current					
Injectivity after injection of 1,000,000 (plus) bbl.	5.8	6.8	55.0	7.2	
Injection rate (August, 1945), average bbl. per day	2,345	2,195	2,240	2,253	Total 9,033
Cumulative injection (September 1, 1945), bbl.	1,822,988	1,160,621	1,002,126	1,014,654	5,000,389

*Re-acidized.

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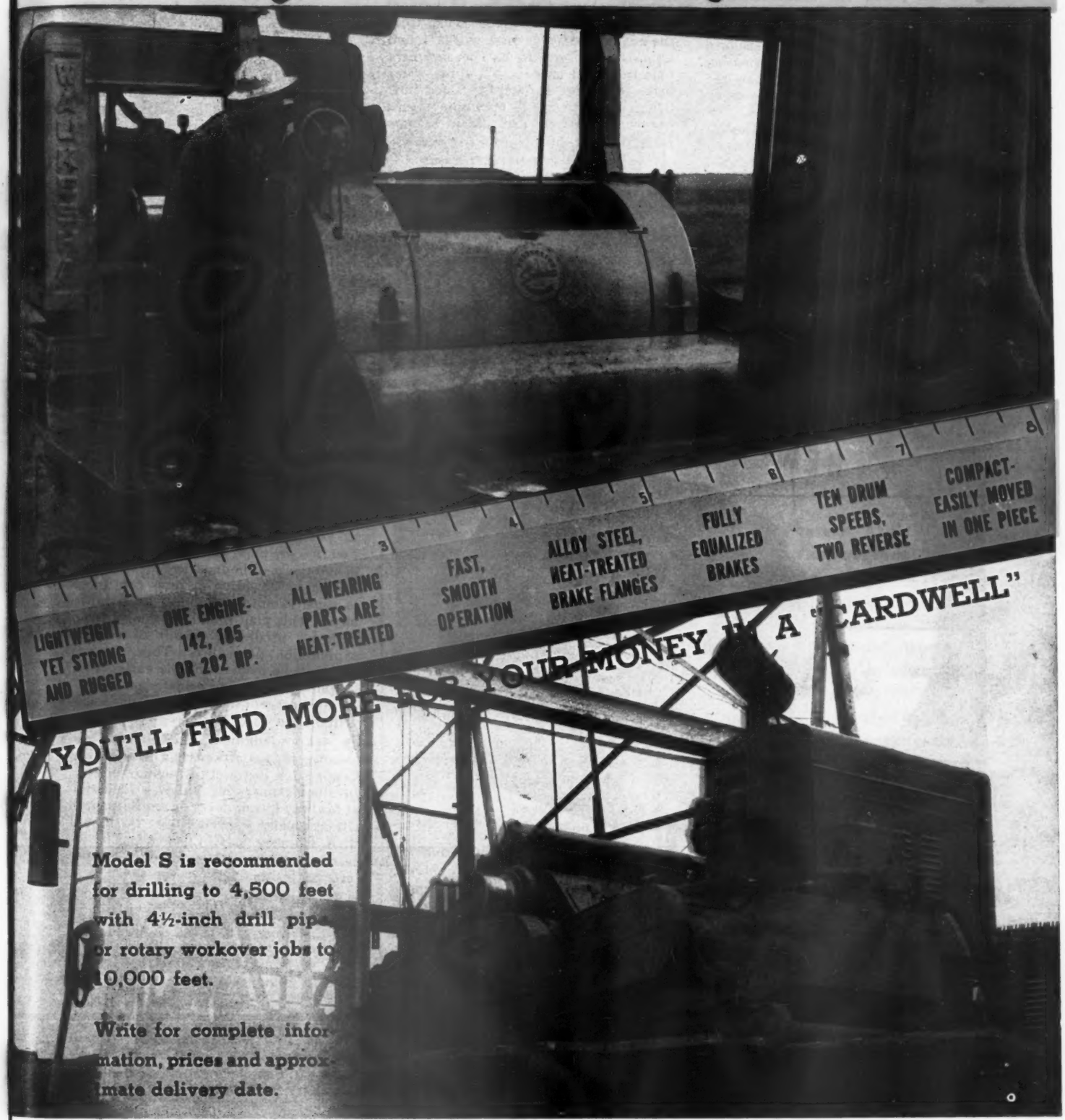
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ciples demonstrated at Midway are applicable to all types of pools. Some conditions that now appear simple at Midway are known to be difficult and complex in several of the other pools whose projects are getting under way.

● **a. Oil pools.** The maintenance of pressure in thin-sand oil pools covering large areas should be found controlled to an important extent by the resistance of flow of oil through the formation across the pool. Within such pools the transmission of pressure is necessarily through the oil. For pools in which the resistance to flow is high, pressures on the flanks will have to be maintained considerably higher than the internal pool pressure desired.

● **b. Gas and condensate pools.** Favorable conditions for uniform distribution of pressure are found in the case of a high-pressure permeable gas sand wherein the pool is underlain by or surrounded by water. Depending on the degree of uniformity and continuity of the formation beyond the edges of the pool it may be expected, from theory, that the augmented water drive will be found almost as uniform in its encroachment pattern as the strongest natural water drive would be. In one Louisiana pool being considered, the operation would permit the operators to obtain income from the sale of gas instead of being obliged to cycle to maintain pressure. At the same time pressure maintenance is possible at a lower cost. It is likewise believed, that, inasmuch as the formation in the Louisiana pool is unusually uniform in permeability, greater recoveries of gas and liquid can be obtained by induced water drive.

The principle of the technique has been described as a simultaneous combination of secondary and primary methods. An important difference between the methods is found in the amounts of water required ultimately for individual injection wells. Pressure-maintenance wells are scheduled for volumes up to 50,000,000 bbl., and are required to retain their capacities to take water for 30 years or more. Typical water-injection wells in the Bradford field receive 70,000 bbl. over a 7-year period. Before the quotas all have been injected, the Bradford capacities to receive water are frequently found reduced to one-fourth of the original. Inasmuch as high and sustained capacities are required in pressure-maintenance projects, considerable attention to injection conditions is required. Among factors to be controlled are: Well completion, control of swelling of clay minerals, and compatibility of the waters to be mixed. Clear water is a requisite.

Although water drive is widely advocated, there are some important instances where gas-cap injection should be applied in combination with water injection and others where gas-cap injection[6] is found extremely advantageous. Each pool requires study as early as possible. This would be facilitated first by drilling with wide spacing to define the pool boundaries, then by producing for a period at rates controlled to some extent by engineering requirements. This plan would provide suitable data for predicting results of various exploitation procedures. Thus, factual data will be made available early; and, if wide spacing is to be satisfactory under the procedure accepted, additional drilling can be avoided.

● **Acknowledgment.** The effective assistance of the Arkansas Oil and Gas Commission is gratefully acknowledged. Invaluable operating aid was rendered at Midway by employes of the Barnsdall Oil Company, especially H. D. Jones, R. B. Chesney, L. C. Carner, and V. B. Harris, the last petroleum engineer and foreman for the joint project.

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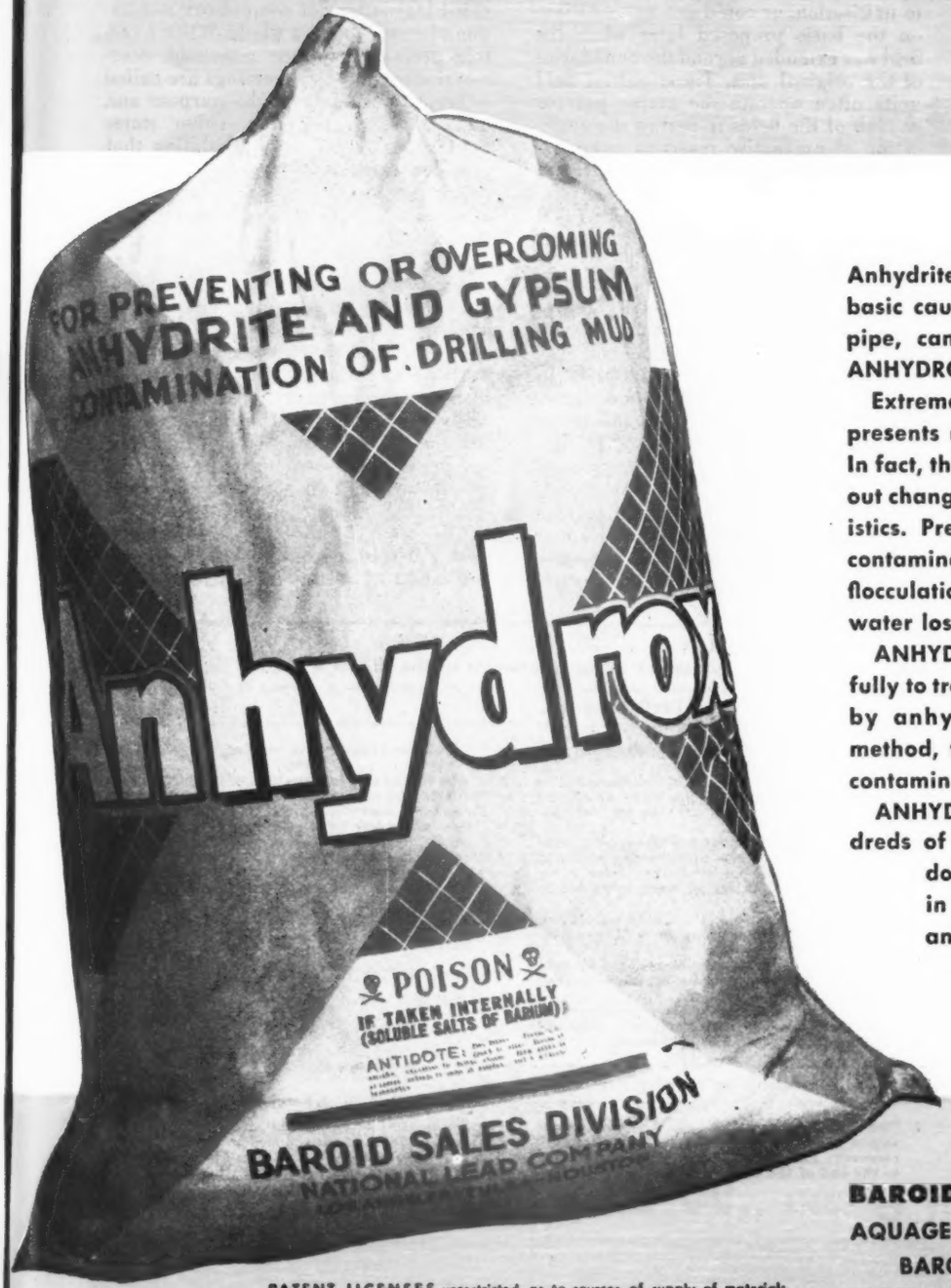

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ECONOMICS OF COMPLETE UNITIZATION OF FIELDS

By **K. MARSHALL FAGIN,** *Field Editor*

Unit operation facilitates application of pressure maintenance and other reservoir engineering to obtain maximum recovery.

COMPLETE unitization of all working and royalty interests in an oil or gas field removes the lease lines as obstacles to the employment of production methods and engineering practices that will obtain the highest ultimate recovery of hydrocarbons from the reservoirs at the lowest cost. The earlier in a field's life that unit operation can be introduced, the greater the opportunity is for applying "preventive" reservoir engineering measures to take the full advantage of the natural reservoir energy, structural conditions, and reservoir formation characteristics.

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These axiomatic facts have been recognized more and more by alert and progressive oil production men, including executives and engineers, for more than 20 years, but the competitive urge to maintain free and independent producing organizations to handle individually held properties in the oil fields has confined complete unit operations to those few fields where every operator could voluntarily reach an agreement regarding the form and nature of the operations to be conducted by a unit management.

Many so-called field units, therefore, operate only parts of fields and reservoirs, because all operators could not agree to join on the basis proposed prior to unitization, or could not agree to join on the basis proposed later when the field was extended beyond the boundaries of the original unit. These partial field units often operate the major part or enough of the fields to permit the application of preventive reservoir engineering measures that will result in greater production at less cost, but in many instances gas or water pressure maintenance programs have to be limited or delayed due to the presence of lease lines. Complete unitization of the field and its edge properties is the most important prerequisite to the application of conservation measures in most fields.

● **Most units organized voluntarily.** In view of the fact that unanimous agreement had to be reached voluntarily in most cases on all the details of unitization, it is surprising that so many complete units have been formed. This reveals a genuine spirit of give and take, for no formula has ever been devised that would divide the benefits of unitization among the participants with absolute justice. The division of benefits can be adjusted from time to time during the life of a field, however, to give all participants substantially their fair share of the earnings, and, due to additional oil recovery, the earnings of each participant should be more than without unitization.

Louisiana and Oklahoma are the only states so far as we know that have provided legislation for compulsory unitization of reservoirs as a whole. When a certain percentage of the leasehold interests desire to unitize, hearings are called to review and approve the purpose and methods of organization. Other states such as Arkansas have legislation that provides for compulsory unitization of drilling units. Otherwise, unitization is achieved solely by mutual consent of all the operators.

Although the purpose of complete unitization is usually to develop and produce a field with maximum engineering efficiency to obtain the highest ultimate recovery with the least investment in wells and equipment and at the lowest lifting expense, many operators, especially those with small interests, realize that their voice in the control of the unit operation will be insufficient to alter materially any unit practices that do not suit them.

● **Persuasive diplomacy aids unitization.** For this and other reasons, the organization of a unit in a field that in-

TABLE 1
Some of the advantages or reasons for complete unitization at various stages in the life of a field.

A. Operating or "working" interests.

I. *Prior to development in newly discovered fields.*	II. *Prior to primary depletion in fully developed fields.*	III. *Prior to secondary recovery in stripper fields.*
1. Development of the oil or gas reservoirs can be conducted in an orderly and prudent manner.	1. Production of oil and gas can be managed to obtain the maximum advantages from the natural reservoir energy and the highest ultimate recovery.	1. Air or gas driving, waterflooding, or repressuring operations can be planned and managed to take maximum advantage of any natural energy left in the reservoir: the shape of the structure; the characteristics of the reservoir formation, and the wells and surface equipment that remain at the time of unitization.
2. The drilling of many unnecessary wells may be saved.	2. Much surface equipment can be saved by centralizing tank batteries and treating systems.	
3. The wells can be spaced most advantageously with respect to the gas-oil or oil-water contacts, in order to provide maximum total recovery from each well with a minimum of high gas-oil ratio or water production.	3. High gas-oil ratio wells can be closed in or converted to gas injection wells to maintain reservoir pressure.	
4. Well and surface installations can be planned to obtain maximum usefulness with minimum investment and operating expense.	4. High water-oil ratio wells can be shut down or converted to water injection wells to maintain reservoir pressure.	
5. Initial damage to wells and reservoirs with attendant life-long operating difficulties can be avoided by complete unitization prior to development.	5. Considerable savings may be realized by centralization and consolidation of the field labor force.	
	6. Pressure maintenance or other conservation measures may be instituted with complete freedom from "lease line" problems.	

B. Non-operating or royalty interests.

1. The royalty owners will benefit individually by the possibility of increased ultimate recovery of oil, gas, condensate or natural gasoline, and by receiving payments as long as any other royalty owners.	1. The royalty owners will benefit by the conservation measures introduced to obtain greater recovery, and by extension of their interest to the end of the whole field's life.	1. The royalty owners will benefit by the conservation measures introduced to obtain greater recovery, and by extension of their interest to the end of the whole field's life.
2. Distress or low prices are not apt to result from development of a large field operated by a unit.		
3. A small isolated pool developed by a unit is a more attractive connection for pipe lines than one developed competitively.		

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TABLE 2
Some of the disadvantages or hindrances to complete unitization at various stages in the life of a field.

A. Operating or "working" interests.

I. *Prior to development in newly discovered fields.*	II. *Prior to primary depletion in fully developed fields.*	III. *Prior to secondary recovery in stripper fields.*
1. Some lease owners may be unable to advance their proportional share of development costs.	1. Some operators desire to retain their own production personnel in control of their properties. This is often the case where an operator's properties are advantageously situated in a field, or when his producing cost is lower per barrel than his competitors.	1. Some operators desire to retain their own production personnel in control of their properties. This is often the case when an operator's properties are advantageously situated in a field, or when his producing cost is lower per barrel than his competitors. They fear loss of direct control of their properties by exchange for an interest in the whole field.
2. Some may believe they cannot afford or else do not want to wait until a unit can be formed to begin development.	2. Other operators may not desire unitization because of previous difficulties with other unit organizations or the prospective operator of the proposed unit.	2. Other operators may not desire unitization because of previous difficulties with other unit organizations or the prospective operator of the proposed unit.
3. Some believe they will get a larger interest in a unit by developing their own properties.	3. Other operators may not agree to the feasibility of the program for the proposed unit.	3. Other operators may not agree to the feasibility of the program for the proposed unit.
4. Some prefer to develop their own leases, in order to maintain and control their own drilling and producing operations.	4. Other operators may not be satisfied with the calculations of their interest in the proposed unit.	4. Other operators may not be satisfied with the calculation of their interest in the proposed unit.
5. Most of the "hold-out" operators honestly believe in conservation and cooperative engineering measures to obtain the maximum efficient recovery, but do not think unitization necessary at this time.	5. Other operators may believe that a cooperative program will be as successful and workable as unitization.	5. Other operators may believe that a cooperative secondary recovery program will be as successful and workable as unitization.

B. Non-operating or royalty interests.

1. Many of the royalty owners are unfamiliar with unit operation, and fear that fewer wells will result in less ultimate oil production.	1. Many royalty owners do not understand the methods of calculating their interests in a proposed unit, and some who will receive less (to begin with) will not join until they fully understand the advantages to be gained by greater recovery and a longer-lived interest.	1. Some royalty owners may not be satisfied with their prospective share of the total royalty in a field unit, but most recognize that unitization for secondary recovery will mean much added income.
2. Other royalty owners want competitive development and a rapid rate of cash return from their interests. They fear "controlled" operation.		
3. Others cannot or do not want to understand the methods of calculating their interests in a unit.		

volves many operators is almost as much a problem in diplomacy as it is a problem of formulating an equitable division of interest and plans for operation, and, although many units have been formed and others are being drafted, each operator not only weighs carefully the advantages against the disadvantages, but also the effect of unitization upon his other producing operations and upon his prestige as a prudent operator.

Most unit operations represent, therefore, a triumph of one or a few operators in persuading the others in the field that their plan for unit operation offers more advantages than disadvantages. In addition it should be added that the initial unitization proposals often are made by operators with relatively small interests in a field, and not by the larger operators who will gain the most.

● **Early unitization should include flanks.** The economic advantages of complete unitization are greatest when a field is unitized prior to development, that is, before the bulk of the wells are drilled. Unitization at this time should include an area two or three times the most optimistic geological estimate of the ultimate size of the field, in order to obtain complete control of possible flank producing areas. Too many units have been blocked on a conservative basis, and edge operators are usually very reluctant to join a unit on an acre-foot of pay sand basis. They realize that their position on the flank may sometimes be more valuable than any formulas indicate.

Preliminary inclusion of much unproductive acreage might save much bargaining at a later date, and the unit for most new fields might well afford to pay rentals and other carrying charges until the field limits are outlined by drilling. Then, the acreage could be released to the original participants.

● **Much unnecessary drilling may be saved.** Unitization prior to development enables the unit to space the wells most advantageously with respect to the contours of the structure and the gas-oil and water-oil contacts. This is especially desirable in a field with more than one producing reservoir, inasmuch as spacing requirements may vary considerably from reservoir to reservoir due to differences in producing formation thickness, permeability, and porosity as well as to differences in reservoir fluid characteristics.

The savings that accrue as a result of drilling only the wells that are necessary to obtain the highest recovery may amount to millions of dollars in fields of average size. The exact amount saved in any particular case will naturally be only an arbitrary estimate, but very substantial savings are probable, especially in states or areas that do not control or limit the number of wells that may be drilled on a lease.

● **Unitization advantages listed in Table 1.** Some of the other reasons for complete unitization prior to development are shown in Table 1. Some of the disadvantages or hindrances to complete unitization are given in Table 2. No attempt is made to list all advantages or disadvantages, inasmuch as these vary from field to field and from unit to unit. Likewise, some of the reasons given are not applicable to all unitization proposals, but they are reasons that have been advanced for or against particular unitization proposals with which the writer is familiar.

The reasons for and against complete unitization are divided into three parts according to the age of a field, and subdivided according to the type of interest owned. Comparison of the advantages at each period indicates the diminishing character of the returns that may be expected from complete unitization as a field becomes older, and yet the older it grows, the more necessary it often becomes to the operators to unitize in order to apply secondary recovery measures most effectively.

● **Unitization of fully developed fields.** Complete unitization of a field after it is fully developed and before the natural reservoir energy has been dissipated by heavy and rapid production will sometimes be as profitable to all the operators and as important to conservation as unitization prior to development. This is especially true in fields that have been developed under the conservation rules and regulations promulgated by some of the progressive and conservation-minded state commissions, but in general, much money is lost in drilling unnecessary wells and in not developing the fields as natural units.

Although many of the disadvantages or hindrances to complete unitization may seem important to the individual operators at the time the unit is proposed, it is doubtful that any of them are ever so serious that a little bargaining could not dispose of them to the mutual advantage of all. In cases where the objections to complete unitization appeared insurmountable, the operators have often been able to reach cooperative agreements or partial unitizations that resulted in conserving reservoir energy and obtaining more oil at a lower cost per barrel.

● **Cycling requires binding agreements.** In gas-condensate fields, complete unitization or a binding cooperative agreement is almost always a necessity prior to the building of a cycling plant, in order to protect the plant owner from ruinous dilution of the incoming "wet" gas either by other nearby cycling operations or by retrograde condensation in the reservoir due to heavy with-

drawal and sale of the gas by other operators in the field.

The royalty or other non-operating interests in a field need to be unitized in order to effect complete unitization. If the royalty owners do not unitize, the operator of a unit is handicapped in many ways by the necessity of observing lease boundary lines and may often have to drill unnecessary wells, erect and maintain unnecessary tank batteries, and limit his pressure maintenance programs. Furthermore, from the royalty owner's standpoint, his income will cease when his lease is abandoned whereas by joining the royalty owners' unit he would continue to receive payments until the entire field is abandoned.

● **Royalty owners benefit by unitization.** The advantages and disadvantages of complete unitization insofar as the royalty owners are concerned are shown in Tables 1 and 2 below the working interest section. It is highly improbable that any of the royalty owners have anything to lose by unitizing. It is largely a matter of explaining the unitization program to them and explaining the methods of calculating their new interests in the field as a whole.

The list of disadvantages are simply fears. Every royalty owner wants to have a well drilled on his particular tract of land, and many of them want to receive large initial checks (the income tax position of some may have altered this desire), and most of them distrust any plan or program that promises to impede fulfillment of either desire, but it is usually well worth the operators' time to allay these fears and point out the mutual economic advantages of complete unitization, that is, not so much money now, but a stabilized rate or production, more oil, and more money in the years to come.

● **Many examples of "field" unit operations.** The history of the struggle of progressive oil production men to organize the operators of individual pools into unitization for the conservation of oil and gas as well as for the economic good of the operators is well outlined in Part 2 of the printed reports of the Petroleum Investigation of 1934[1].

Some of the older examples of complete or partial unit operation are Yates, Hobbs, Van, Kettleman Hills, Lucien, Salt Creek, and Sugarland. Some of the more recent examples are South Burbank, Haynesville, La Gloria, Erath, and Cotton Valley.

The enlightened trend toward both unitization and more effective state control of well spacing and withdrawal rates is assurance that the oil industry and the people as a whole will benefit materially by the conservation of our natural gas and petroleum. We have seen it wasted in flares and river bottoms at many places. It will not last forever. It must be saved.

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RULE FOR FINDING EFFICIENCY OF GAS FIRED BOILERS

By **W. F. Schaphorst**

As every petroleum engineer, mechanic, and operator doubtless knows, to measure boiler efficiency we are usually told to "find the heat in the steam evaporated by the boiler and divide it by the heat given up by the fuel." In other words, boiler efficiency, like all other efficiencies, is equal to output divided by input.

That being the case, why bother about steam at all if we know the quantity of heat that escapes up the chimney? Isn't it logical to conclude that the heat that doesn't escape up the chimney is absorbed by the boiler? To determine the output, then, simply subtract the heat lost up the chimney from the original heat in the fuel. On that basis of reasoning we get this formula:

$$\frac{\text{(Heat in fuel)} - \text{(Heat lost up chimney)}}{\text{(Heat in fuel)}} = \text{Boiler efficiency.}$$

Obviously, with ideal combustion of fuel, and with a boiler that is perfectly insulated so that all waste heat would be confined to the chimney, the above formula would give very accurate results. But of course combustion is not always ideal, and regardless of the thickness of insulation *some* heat is bound to pass through the boiler walls.

Consequently, rather than be guided entirely by theory, this writer studied the averages of a number of authoritative tests where the boiler efficiencies varied from a trifle over 60 per cent to more than 80 per cent. The heat value of the fuel was known and considered in each case, together with the temperature of the chimney or exit gases. As a result the following rule has been developed for gas fired boilers:

Multiply the chimney gas temperature in degrees F. by 35.5 and divide by the heat value of the gas in B.t.u. per cubic foot. Subtract the result from 100. The remainder is the approximate boiler efficiency in per cent.

Anticipating that some readers may ask, "Where does the 35.5 come from?" I believe that will be understood by throwing the above rule into the form of the first formula given here, namely,

$$\frac{H-h}{H} = \frac{1-h}{H} = \text{Boiler efficiency.}$$

Where:

H = heat in the fuel;

h = heat in the chimney gas.

Multiply both sides of the above by 100 to express efficiency in per cent. It becomes:

$$100 - \frac{h \times 100}{H} = \text{Efficiency, per cent.}$$

In my calculations I found that 35.5 multiplied by the chimney gas temperature approximated closely the heat in the chimney gas multiplied by 100. And that is where the 35.5 came from. In other words, the 35.5 is an empirical constant based entirely on experimentation.

The above boilers, by the way, were fired by natural gas having a heat value varying from 980 to 1040 B.t.u. per cu. ft. In the event, therefore, that your heat values are considerably different the writer would advise caution.

For example, in one of the above tests the figures give the maximum chimney gas temperature as 625°F., at which point the boiler efficiency according to actual test was 78.3 per cent. The above new rule gives its efficiency as 77.8 per cent, or one-half of one per cent off. The minimum temperature of the chimney gases during the same test was 443°F., at which point the boiler efficiency according to actual test was 84 per cent. The above new rule gives its efficiency as 84.3 per cent, which most engineers would regard as being pretty good.

The writer wishes to emphasize that the above rule is based on good boiler operation. For instance it is possible to obtain a fake result by using so much excess air in combustion, or by admitting so much air into the chimney, that your exit gas temperature will be low, in which event the rule will say that your boiler efficiently is high. Therefore to be sure that the amount of air supplied to the boiler is correct it is advisable to use a CO_2 indicating outfit of one kind or another. Excellent CO_2 indicating and recording devices are now being made and at prices ranging all the way from a few dollars to several hundred dollars, so that every gas burning plant can now easily afford to have one. It is exceedingly important that the percentage of CO_2 be right. Then apply the rule.

In other words the only special instrument that is most likely to be necessary or desirable for making the above simple experiment, or efficiency test, is a CO_2 outfit. Most plants are equipped with thermometers capable of taking chimney gas temperatures. When you have these two instruments you are all set for the test. ★ ★ ★

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SOLID ADSORBENT TYPE DEHYDRATION PLANT PLACED IN OPERATION IN CARTHAGE FIELD

By **FRANK H. LOVE,** *Managing Editor*

EXCLUSIVE

Gas dehydration becomes an integral part of high pressure gasoline plant design when the residue gas from the plant is delivered to transmission lines. The problem becomes more exacting when ground temperatures are low. The trend is toward the use of higher transmission pressures and as the line pressure increases the temperature at which hydrocarbon hydrates will form is higher. The problem is aggravated further when a plant situated in the South must deliver gas for long distance pipe line transmission to northern sections of the country. This is particular so in the fall when cooling water and gas temperatures are still high in southern locations because then the gas must be delivered to the pipe line with sufficiently low water dewpoints to withstand pipe line exposure to sharp drops in temperature in northern climates. When large spreads in dewpoints between plant inlet and outlet gas must be effected the solid adsorbent type dehydrating unit provides great flexibility.

United Gas Pipe Line Co. unit is designed for 100,000,000 std. cu. ft. a day capacity with dewpoint of the outlet gas at 30°F.

United Gas Pipe Line Company has recently placed in operation a unit of this type at its Carthage gasoline plant. Design conditions of the dehydration unit are as follows:

Inlet gas:

Quantity: 100,000,000 std. cu. ft. per day.
Pressure: 1030 lb. per sq. in.
Water dewpoint: 90°F.

Outlet gas:

Water dewpoint, approximately: 30°F.

The gas handled at Carthage comes from a gas-condensate reservoir. Pressure is reduced at the wells to approximately 1150 lb. per sq. in. in the well separators. After metering, the gas and condensate flow into a common gathering system, which enters the plant at two inlet scrubbers. The scrubbers, which are 4 ft. in diam. by 20 ft. high, separate the gas from the high pressure condensate, the latter flowing to a separate processing operation. During temporary operation, pending the completion of the gasoline plant, the gas from the inlet scrubbers now flows direct to the dehydrators. Later the gas will flow through the absorbers and then to the dehydrators.

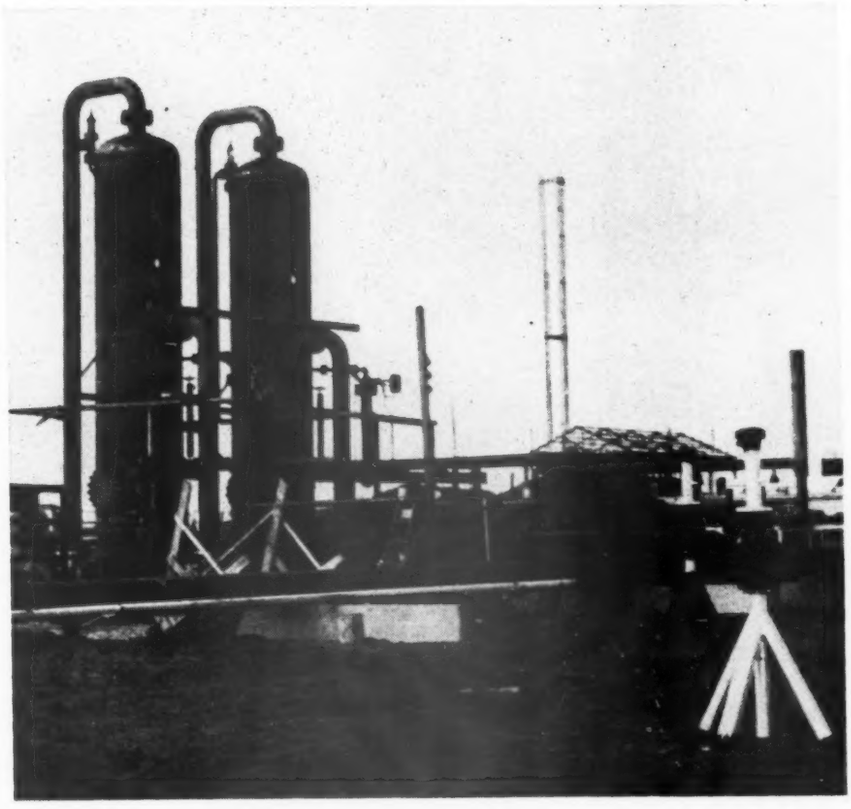
The gas having been in contact with hydrocarbon condensate and water in the liquid phase in the inlet scrubbers will be saturated with water vapor at the scrubber temperature. Small quantities of water may be picked up by the gas in the absorbers from the absorption oil, for the temperature of the gas increases as it flows through the absorber.

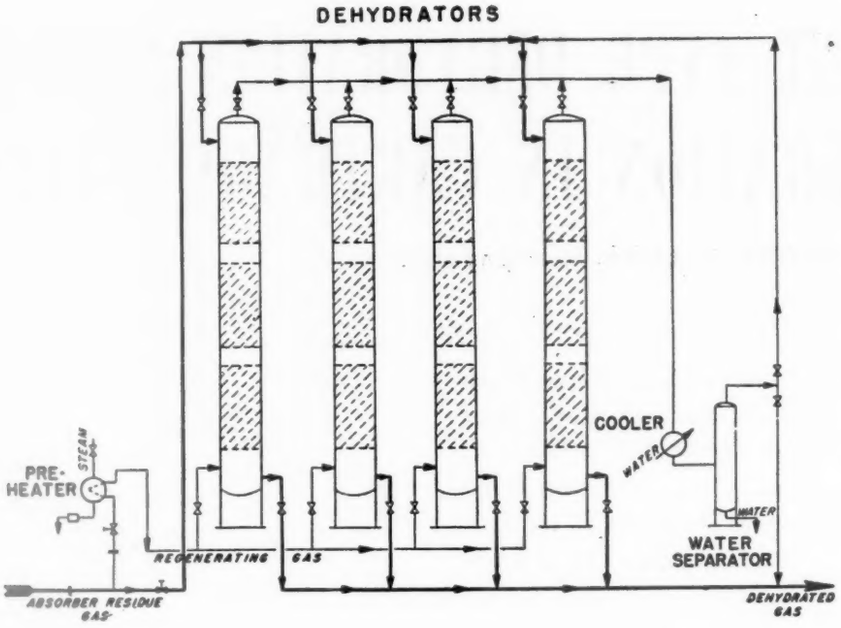
The main gas stream flows downward through the dehydrators and the water vapor is removed by adsorption in the desiccant bed. In a 24-hr. period the desiccant will adsorb 4 per cent by weight of water. Dewpoint determinations are made on the dry gas stream to check the efficiency of water removal and determine the time that the dehydrators may remain on stream. The safe time interval is determined by experience and the dehydrators are then placed on a regular schedule. The dehydrators that have just been taken off the line are then connected to the regeneration cycle.

Regeneration is accomplished without depressuring by diverting a part of the main gas stream ahead of the dehydration unit. This regeneration stream, which amounts to approximately 15 per cent of the total flow of gas to the unit, is heated in a tubular heater to 375°F. Steam at 250 lb. per sq. in. is used as the heating medium. The hot gas flows upward through the wet hydrators, gradually raising the temperature of the desiccant bed, which releases the adsorbed water.

The warm gas has a high water-carrying capacity at the elevated temperature and thus conveys the water from the dehydrators to the gas cooler. The cooler

Gas-condensate from the field enters the plant at two scrubbers. Gas is separated from the high pressure condensate, the former flowing directly to the dehydration unit during temporary operation, the latter to a separate processing operation.





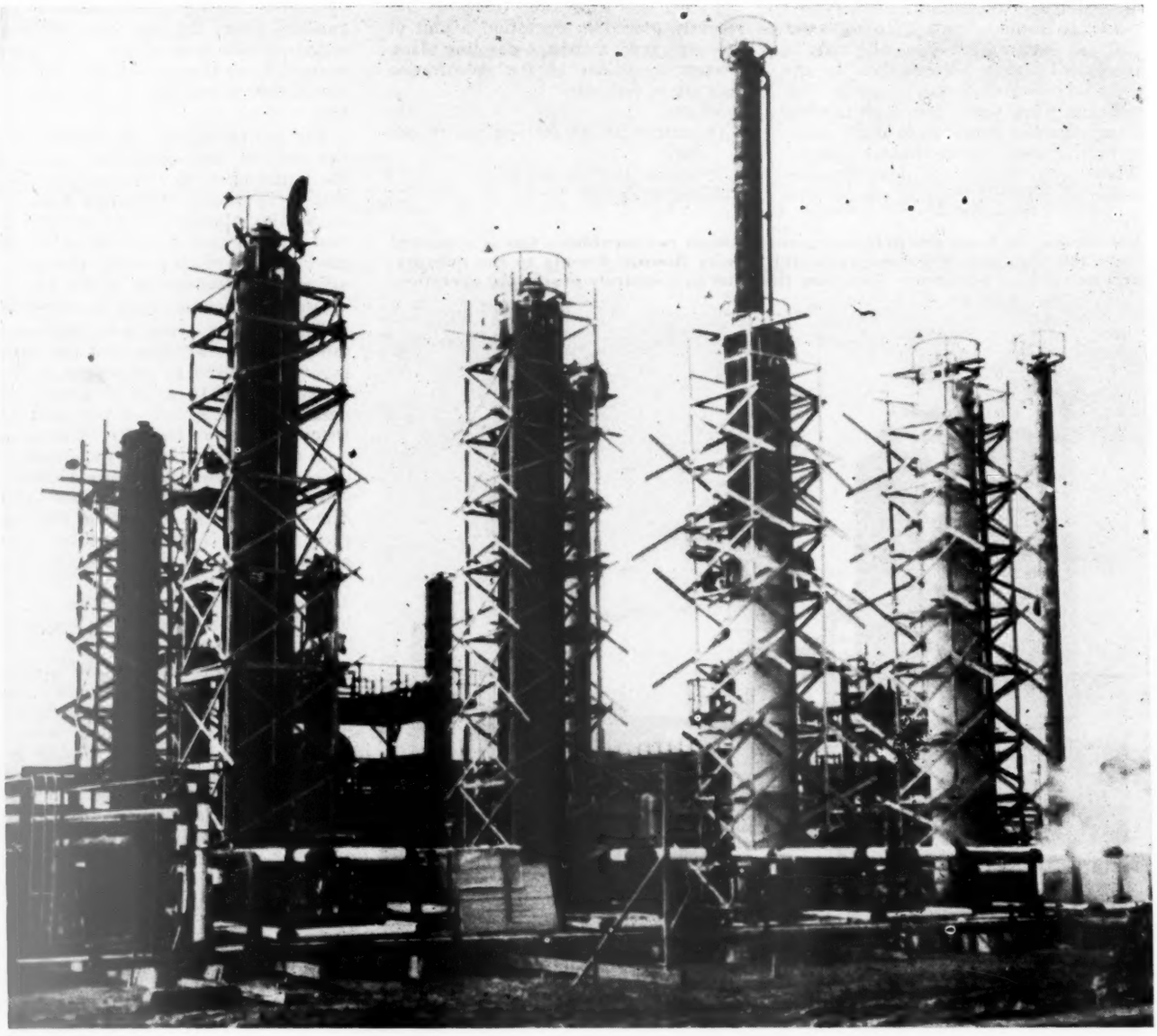
during winter operation of raising the condenses the water and it is removed from the bottom of the water separator.

The cool regenerating gas stream then may either join the main dry gas stream at the outlet of the dehydration unit or be injected into the wet gas stream entering the dehydration unit. This choice is determined by the desired dewpoint of the total effluent from the dehydration unit. The regenerating gas stream will have a dewpoint slightly above the temperature of the water used in the cooler. When mixed with the very dry gas from the dehydration unit the dewpoint of the total stream usually will meet the desired specification. Introducing the regenerating gas into the dehydrator feed, however, insures an extremely dry total effluent gas and has the added advantage

(Continued on Page 156)

Left—Simplified flow diagram of dehydration unit.

Below—In the foreground are shown the four dehydrators. The piping arrangement is such that two dehydrators can be operated in parallel on dehydrating duty while the other two are regenerated. On-stream time is 24 hr.



Wiggins Structure

FLOATING ROOF

General American Transportation Corporation, exclusive manufacturer of new and improved Wiggins products, now offers a new Wiggins achievement.. the Lo-Dek Floating Roof.

This new Lo-Dek roof, specially designed to handle sour crudes, has evolved from the Wiggins Hi-Dek, and has all the same exclusive advantages, including: fire prevention, maintenance of quality of stored commodities, dependability, and flexibility.

The new Wiggins Lo-Dek is an excellent roof that combines service with an assured high investment return.

The heart of good performance is skill and experience, and General American personnel has the "know-how" that springs from more than half a century of successful building, selling and erecting tanks all over the world. Investigate the possibilities of the new Wiggins Lo-Dek Floating Roof in your operation by contacting the General American office in your area.

General American Transportation Corporation

135 South La Salle Street, Chicago

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New York • Washington • Cleveland • Buffalo • Pittsburgh • St. Louis
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during winter operations of raising the temperature of the inlet gas stream well above the temperature at which hydrates will form.

Flowing the regenerating gas upward through the dehydrators during the regenerating cycle has the advantage of removing traces of absorption oil from the top of the bed that were deposited by the main stream of gas while on downflow during the drying cycle. The use of downflow on the drying cycle creates less disturbance of the bed due to pressure drop. The particles of desiccant have less tendency to move, grind against each other, and be lifted from the bed and carried away by the outlet gas stream.

Average natural gas contains 41 lb. of water per million std. cu. ft. at 1030 lb. per sq. in. and a 90°F. dewpoint, and 6 lb. per million std. cu. ft. at 1050 lb. per sq. in. and a 30°F. dewpoint. The size of the dehydrators is dependent on the carrying capacity of the desiccant, the on-stream time cycle desired, and the allowable pressure drop through the bed.

The Carthage dehydration unit contains 4 dehydrator towers 5 ft. in diam. and 50 ft. high with piping so arranged that 2 dehydrators can be operated in parallel on dehydrating duty while the remaining 2 are being regenerated. These units provide for an on-stream time of 24 hr. under the above design conditions. The pressure drop through the unit is approximately 8 lb. per sq. in. Each dehydrator contains 3 separately supported beds of desiccant of equal height with space between beds for redistribution of the gas stream to avoid channeling.

When using 15 per cent of the main gas stream for regeneration and operating with the above water removal the total regenerating time will be about 12 hr. This allows 12 hr. idle time until the regenerated units are again required to go on stream. The time of regeneration depends on the amount of regeneration gas used and its temperature. The temperature of the top of the bed is used as the control point. When the top of the bed reaches a temperature of 325-350°F. the regeneration is complete. The steam heater is then bypassed and cool gas flows through the desiccant bed until it has returned to normal temperature.

The desiccant used at Carthage is an activated bauxite containing 60 to 70 per cent Al_2O_3. Based on similar installations it should have a life of 2 years or more before renewal. The dehydrators are equipped with access openings for the easy replacement of the desiccant.

All equipment is designed in accordance with the API-ASME code for a pressure of 1200 lb. per sq. in. on the gas side. The preheater and gas cooler have gas pressure on the tube side. The tube bundles are of U-tube design using 2 tube sheets on the front end. The first tube sheet is bolted to the shell flange. The tubes are rolled into the tube sheet and extend through it about 10 in. The ends of the tubes are rolled into a second tube sheet that has a high pressure channel bolted to it. This construction allows easy inspection of the tube joints in the high pressure tube sheets. Failure of one of these rolled joints will blow gas into the atmosphere rather than into the steam or water side. One high pressure flanged joint is thus avoided and no high pressure joints are inside the shell.

The dry gas stream from the dehydrators enters directly into the 24-in. transmission line recently laid from the Carthage field to United's Sterlington compressor station, a distance of 142 miles. At Monroe, Louisiana, a tie-in has been made with Tennessee Gas and Transmission Company system, to which is delivered a part of the gas load, the rest going on to Sterlington to augment United's supply to its customers in the Monroe area. Operation of the pipe line is on discharge pressure from the dehydration plant.

The field gathering system that brings the gas-condensate to the plant consists of 103 miles of pipe line varying in diameter from 6 in. to 20 in.

In charge for Stone and Webster Engineering Corporation, contractors for construction of the dehydration plant, was R. M. Wood, construction superintendent. C. W. Hollenshead was the engineer in charge of construction for United Gas Pipe Line Company, and J. D. Hilburn was resident engineer.

★ ★ ★

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...You get the trenching jobs done faster and at less cost... because of their...

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- RUGGEDNESS
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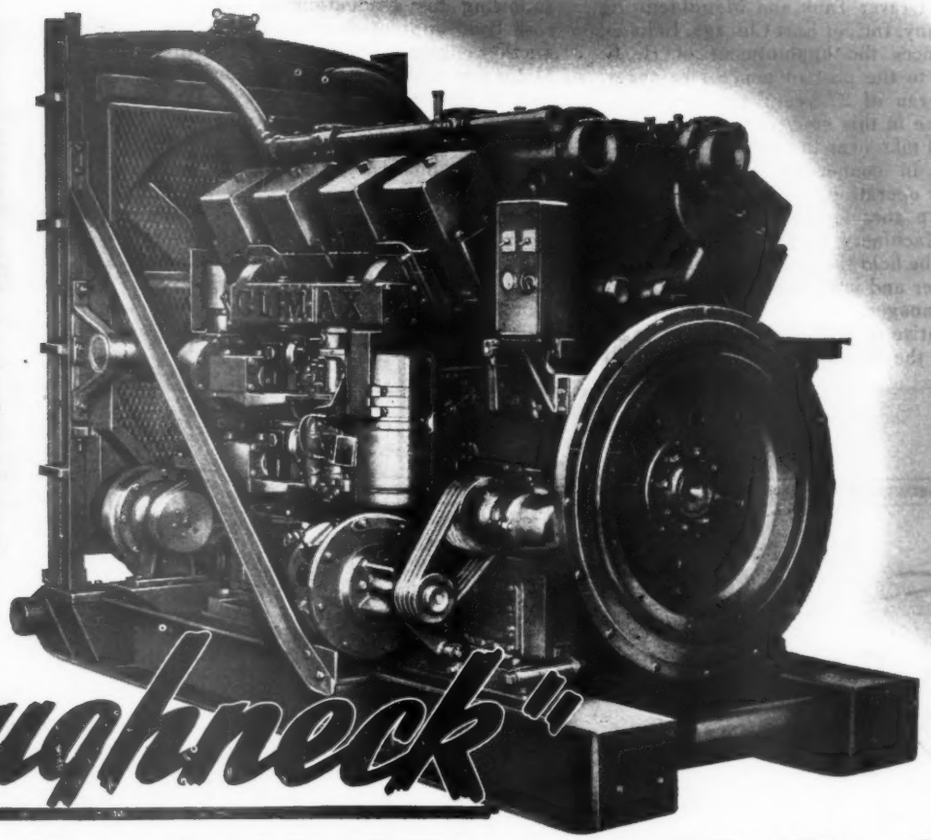
CLEVELANDS Save More... Because They Do More



NEW-COMPACT
Climax VU 280
Rated 280 h.p. at 1100 r.p.m. with radiator, fan and auxiliary equipment, 8 cylinder, 4 cycle, "V" Type 60°.

"Roughneck" RUGGEDNESS for Hard, Deep Drilling!

Climax OPERATING ADVANTAGES

- Rapid acceleration and get-away
- Complete accessibility
- Expert field service
- Parts stocked at all active points

MORE *ON-THE-JOB* POWER

Rated power is one thing. But power and "get-away" to hoist drill pipe fast —extra power for peak loads—rugged, brute power to lug through overloads and to stand drill-crew handling—*these* give this new Climax V-Type Blue Streak Engine *more power on the job!*

Used singly or compounded in pairs or triple series, this compact, valve-in-head Blue Streak Engine is a sturdy, flexible prime mover that accelerates from "idling" to top speed *in seconds.* It operates efficiently and smoothly on natural gas, butane or gasoline.

For complete specification bulletin, write Climax Engineering Company, General Offices, Clinton, Iowa.
Regional Offices: Chicago, Tulsa, New York.

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Builder of Climax DIESELS and GENERATING SETS
CLIMAX ENGINEERING COMPANY

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FACTORY BRANCH
901 Sinclair Building
Fort Worth, Texas

CALIFORNIA DISTRIBUTOR
Climax Engines & Parts Company
2050 Santa Fe Ave., Los Angeles

General manager Graver

The Graver Tank and Manufacturing Company, Inc., of East Chicago, Indiana, announces the appointment of H. G. Sharp to the post of general manager. A veteran of 27 years' production experience in this country and in Europe, he will take over the general manager's duties in connection with the entire Graver operation.

Sharp goes to Graver from the General Machinery Ordnance Corporation where he held the position of production manager and later that of assistant general manager.

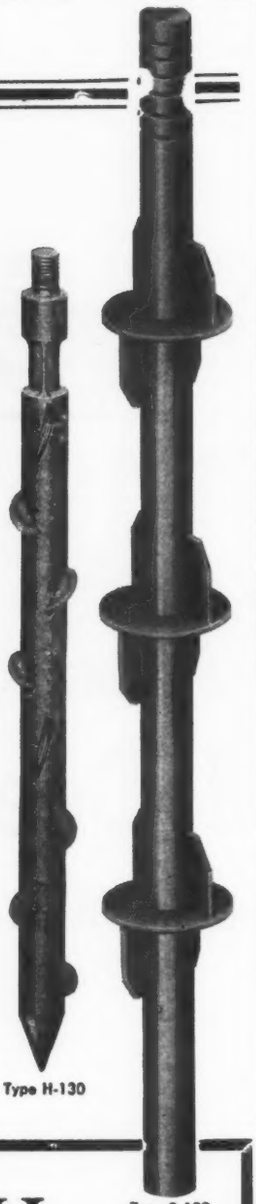
A native of Buffalo, New York, he attended the Sheffield Scientific School of Yale University. In the 12-year period following his graduation in 1918, he rose from apprentice machinist to production engineer with the Pierce Arrow Motor Car Company. He then joined the staff of Day, Zimmerman, Inc., of Philadelphia as a consulting engineer and after several assignments in the United States, organized their European subsidiary.

Sharp has also been associated with the Cyclops Steel Company of Titusville, Pennsylvania; the Transue and Williams Steel Forging Corporation of Alliance, Ohio, and the Hollow Steel Propeller Division of the Curtiss-Wright Corporation.

Introducing

SIW PARAFFIN SCRAPERS

NEW tools that solve an OLD problem



Type H-130

Type B-122

Here are paraffin tools that will keep your wells producing. Offered for sale only after long field tests, models are available for all producing conditions.

Included is Type B 122, designed for automatic operation in flowing wells. Any well with pressure enough to flow can be kept free of paraffin with this tool.

Type H 130 s designed with revolving cutters which scrape the entire inner surface of the tubing.

For Kobe pump units, an especially designed scraper attaches to the macaroni string and prevents deposition in the annulus between inner and outer tubing strings.

Other models available for flowing, pumping and gas lift wells. For latest information on paraffin control, write for literature describing these modern S-I-W tools.

SUNSHINE IRON WORKS

Manufacturers of Oil Field Specialties

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Sohio promotions

R. S. Sauer

E. F. Morrill

The election of Richard C. Sauer as vice president of Sohio Petroleum Company and Edward F. Morrill as vice president of Sohio Pipe Line Company, both subsidiaries of The Standard Oil Company (Ohio), was announced by W. T. Holliday, Standard Oil president.

The new vice president of the Sohio Petroleum Company now holds the position of manager of crude oil and refined products distribution and will continue in that capacity.

Morrill, who is stationed in the St. Louis office of Sohio Pipe Line, joined The Standard Oil Company in 1932. He is now assistant manager of transportation operations, and will carry on the duties of this position in addition to those of vice president.

Buckendale SAE president

Election of L. Ray Buckendale, of Detroit, Michigan, as 1946 president of the Society of Automotive Engineers was announced at the SAE annual meeting in Detroit. Buckendale, who is engineering vice president of Timken-Detroit Axle Company, succeeds retiring SAE President James M. Crawford.

L. R. Buckendale

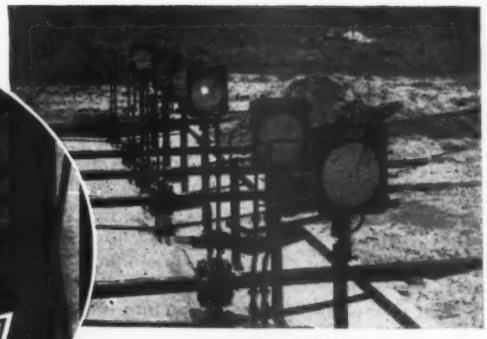
Launches postwar program

Appointment of Russell T. Gray, Inc., Chicago, as advertising and sales promotion consultants for the Wallace Supplies Manufacturing Company, 1308 Diversey Parkway, Chicago, is announced by E. J. DeWitt, vice president and general manager of the Wallace organization, as a part of a broad postwar program calling for greatly increased activity in the industrial field.

Widely known as a pioneer builder of pipe, tube, and bar bending machinery and a leading producer of parts for jet propulsion aircraft engines during the war, Wallace is making its entire engineering, manufacturing, fabricating, and supply facilities immediately available for the solution of manufacturers' production problems.

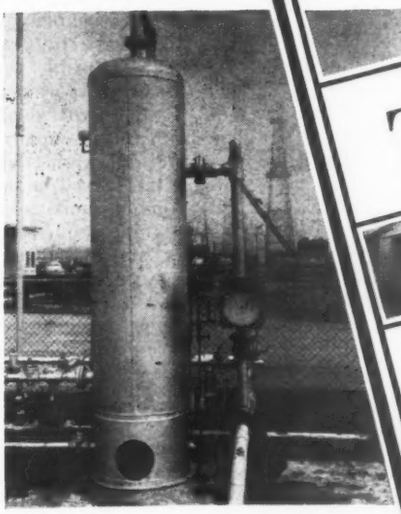
Gasoline Plant Measurement
At Intake Headers

Measurement To
Fractionating Column



Repressuring Station
Measurement

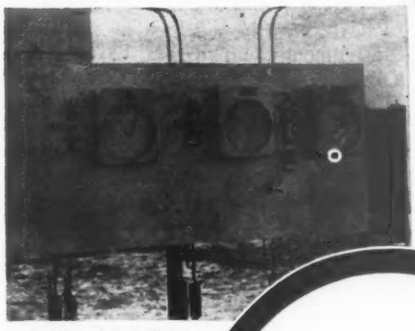
HERE
THERE
EVERYWHERE



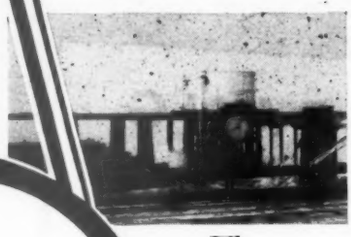
Metering From Oil Field Separator

Mixing Header Measurement

Measurement To and From
Absorbers and Stills



Panelboard Installation
In Field



Gulf
Field Installation

Metering On Intake
Headers

EMCO-McGaughy Integrator
Mechanically computes orifice meter charts with speed and accuracy.

EMCO RIFICE *Meters*

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PITTSBURGH EQUITABLE METER DIVISION
ROCKWELL MANUFACTURING CO.
Main Offices: Pittsburgh 8, Pa.
Atlanta Boston Chicago Houston
Kansas City Los Angeles New York Pittsburgh San Francisco Seattle Tulsa

Dresser conference

More than 100 executives, salesmen, and engineers of 8 of the 14 member companies of Dresser Industries, Inc., met in their fourth annual sales and engineering conference at the Baker Hotel, Mineral Wells, Texas, January 13 to 16.

Eight tons of various types of equipment for the oil and gas industries, representing Dresser products designed and engineered for these fields, were displayed at the conference, illustrating the breadth of range of the services of the Dresser member companies represented at the conference.

Subjects discussed included research programs and sales plans of each of the member companies, and the overall development program of Dresser Industries as a whole.

Among executives of member companies who spoke at the conference were: C. Paul Clark, president, Clark Bros. Company, Inc.; Hanford Z. Hight, sales manager, Dresser Manufacturing Division; Oscar M. Havekotte, president, International Derrick and Equipment Company; Clarence J. Coberly, Sr., president, Kobe, Incorporated; Arthur R. Weis, president, Pacific Pumps, Inc.; Bernard C. O'Brien, vice president, Roots-Connersville Blower Corporation; Otto Hammer, vice president, Security Engineering Company, Inc., and William E. Gruening, president, Stacey Bros. Gas Construction Company.

Chairman of the conference was John B. O'Connor, executive vice president of Dresser Industries, Inc., long known throughout the oil industry as an advocate of improved methods and modernization.

Made service manager

J. M. Dolan, vice president in charge of sales, announces the appointment of Ralph N. Weber as service manager of Le Roi Company.

Ralph N. Weber

Weber brings to this responsible position the experience of almost 10 years with the company, during which time he has served in various capacities in the catalog, purchasing, and accounting departments. He has been active in the service department since July, 1941, as an order analyst and later as manager of the service order department.

In his present position, in addition to the actual service department, he is also responsible for the service repair shop and the extensive field service program.

Add to staff

Twenty-four sales and 11 service engineers have been added by the Brown Instrument Company and have been assigned to branch offices of Minneapolis-Honeywell Regulator Company of which the Brown company is the industrial division.

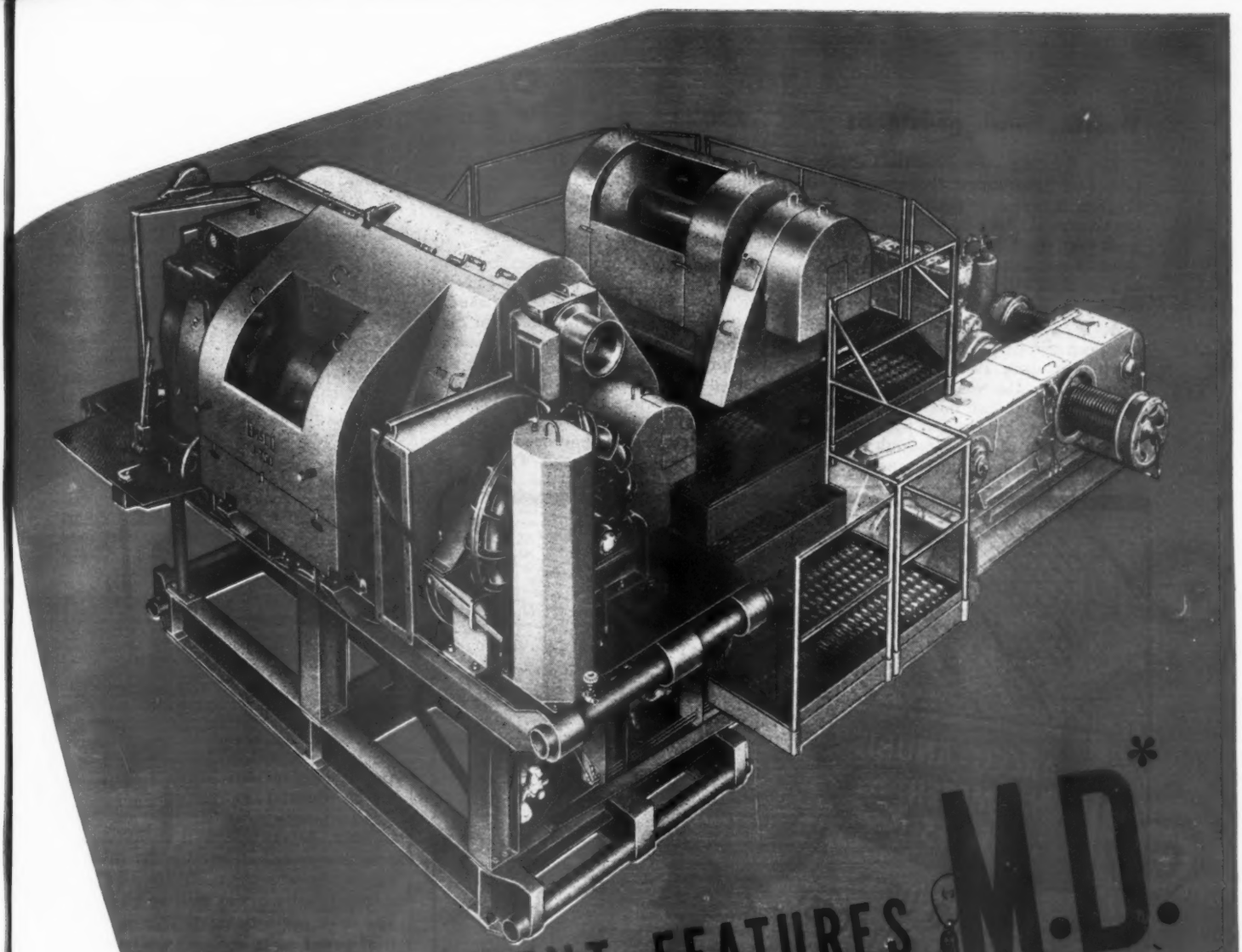
The sales engineers and the offices to which each has been assigned are as follows:

D. L. Russell, assigned to Boston; A. F. Cecere, to Hartford, Connecticut; J. A. Rorex, to Houston, Texas; R. Mitchell, A. D. Mayo, Jr., and H. W. Greisback, Chicago; C. C. Spousta, Jr., and A. R. Willy, Indianapolis; D. F. DeVine, Portland, Oregon; W. H. Palmer and Ross Hubley, Minneapolis; J. Dunlap, Toledo; H. W. Araucz, Detroit; A. T. Challman, San Francisco; H. T. Noonan, Buffalo; L. T. Macgill and A. M. Zellar, Philadelphia; C. McIntire, Cincinnati; R. D. Bailey, Washington, D. C.; J. F. Stein, St. Louis; H. W. Sinewe, Pittsburgh; R. A. Wolfe and E. G. Brown, New York City, and R. F. Bruckart, Cleveland.

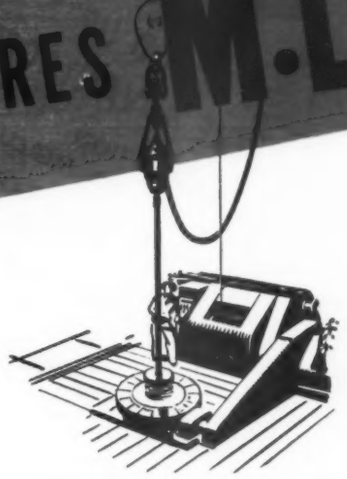
The service engineers added to the staff and the cities to which they have been assigned are:

G. F. Neill and C. Vivion assigned to Atlanta, Georgia; W. W. Weaver, to Boston; J. J. Asklar, Hartford, Connecticut; C. Hornbacker and J. P. Chuchman, Chicago; M. T. Glass, Dallas; A. T. Nicholls, Buffalo; A. Bernard, Montreal, Canada; O. P. Kelly, Syracuse, New York, and H. E. Luther, Indianapolis.

SPECIFY
SPANG
FOR THE BEST IN CABLE TOOLS
SPANG JARS
Fig. D322
THE HIGHER STANDARD
The steel specifications and the process of manufacture of Spang Jars are the result of long intensive study, field performance, and productive experience. Each step in making the forging is carefully planned, executed, and thoroughly inspected. The heat treatment is done in modern specially built furnaces with heat recording instruments, under the supervision of personnel with long experience.
For safety, efficiency, and long life, there is no substitute for Spang Cable Tools —SPECIFY SPANG.
SPANG & CO.
BUTLER, PA.
YOUR DEALER SELLS SPANG TOOLS



EMSCO EQUIPMENT FEATURES M.D.*



THE EMSCO J-750 DRILLING RIG

Here is a 750 horsepower unit designed for deep drilling, yet has little increase in weight, and no sacrifice of safety factors over units of shallower depth ratings. The complete rig consists of draw works, selective speed transmission, compounding transmission, engines and power slush pump. Painstaking care in its design and engineering, the use of highest quality materials and workmanship in its manufacture, provide a smooth, easily handled, efficient drilling rig—a rig with Maximum Drillability.

Smooth dependable performance, fewer shutdowns, longer life . . . these are the characteristics built into every piece of Emsco equipment. They have what we call Maximum Drillability, for each is designed to operate efficiently and economically under all drilling conditions.

EMSCO DERRICK & EQUIPMENT COMPANY

HOUSTON, TEXAS • LOS ANGELES, CALIF. • DALLAS, TEXAS.

EMSCO

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* MAXIMUM DRILLABILITY

Westinghouse president

The Westinghouse Electric Corporation has announced the election of Gwilym A. Price as president, succeeding George H. Bucher, who has resigned from that office. Under a recent amendment of the corporation's bylaws, Price as president will be the chief executive officer.

A. W. Robertson, who as chairman has been the corporation's chief executive officer since 1929, has reached retirement age. He was elected chairman of the Westinghouse board of directors under the new bylaws and will continue as a member of the Westinghouse organization in a less active capacity.

Bucher was elected vice chairman of the board of directors and will continue to serve as chairman of the Westinghouse Electric International Company, which handles all export business of the parent company, and will have other active duties.

At the age of 50 Price is one of the country's youngest directing heads of a major corporation. He was elected a vice president of Westinghouse in September, 1943, and had been executive vice president since May, 1945. He was elected a member of the corporation's board of directors in January, 1945.

Prior to his election as an officer of Westinghouse, Price had been president of the Peoples-Pittsburgh Trust Company of Pittsburgh, Pennsylvania, since January, 1940, following 3 years as its vice president in charge of trusts. He has served as a trust officer since 1923 and as a vice president of the bank since 1930.

Price is a director of the Blaw-Knox Company, South Penn Oil Company, National Union Fire Insurance Company, and the Peoples-Pittsburgh Trust Company. He presently is serving as vice president and director of the Zoar Home; general trustee of Allegheny College at Meadville, Pennsylvania; and as trustee of the Elizabeth Steel Magee Hospital of Pittsburgh and the Pennsylvania College for Women.

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JUST ADD UP THE ADVANTAGES!
NO FRICTION
NO MERCURY
NO STUFFING-BOX
NO LEAKAGE
MEASURES AIR, OIL, GAS, STEAM OR FLUIDS
And then add to these the rugged construction, fully automatic safety by-pass valve; easy calibration with its lack of later adjustments, and you have a sturdy, dependable meter, free from operating troubles and maintenance problems, yet delicately sensitive to the smallest differential changes, and accurate under all operating conditions.
SEND FOR BULLETIN
AMERICAN RECORDING CHART CO.
3113 E. 11th St. Los Angeles 23, California
SEND FOR COMPLETE LIST OF ARCCO CHARTS

Heads new department

Established by Continental Motors Corporation of a general service and distributor sales department under the direction of C. Wheeler Johnson, newly elected vice president, is announced by C. J. Reese, president.

C. W. Johnson

The new department will assist distributors and dealers in improving their service to users of Continental engines throughout the country, he said. It will coordinate all service activities in connection with the company's large industrial customers as well as all service and sales promotion activities on industrial power units and transportation engines as they relate to distributors.

Johnson became associated with Continental a year ago, after 17 years with the Oliver Corporation.

Creation of the new general service and distributor sales department will not alter or affect Continental's airplane engine division, which has an entirely separate service and distribution set-up. Reese said.

Open Detroit office

Tube Turns, Inc., Louisville, Kentucky, has opened an office in Detroit, at 713 Ford Building, in charge of Jack Ellsworth, it is announced by John G. Seiler, the firm's vice president and general sales manager. Ellsworth will represent Tube Turns' forging and welding fittings divisions, and his territory will include Michigan, Northeastern Ohio, North Illinois, and Indiana, except Whiting and East Chicago. Before assuming his new post, he was assistant district manager of the Midwest territory, with headquarters in Chicago.

Jack Ellsworth

OTIS Safety Valves are removable pressure operated type valves — easy to run — easy to pull — without loading the well. Pictured above is an OTIS service crew completing a Safety Valve installation with the use of a lubricator and high pressure stuffing box.

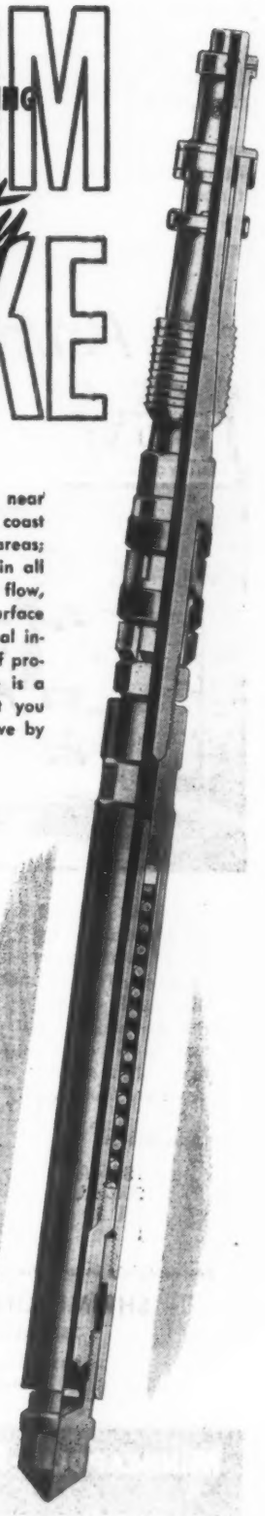
..with an

OTIS

STORM CHOKE

TYPE FB REMOVABLE TUBING

Safety Valve



For flowing wells located in or near highways, rivers, lakes, bays, or coast lines; in storm or seasonal flood areas; in industrial or town sites; — and in all other critical zones where wild flow, caused by failure or damage to surface connections, might result in personal injury, property damage, or a loss of production — an OTIS Safety Valve is a "must"! Remember, it's not what you spend for safety. It's what you save by having it!

The OTIS Type FB Removable Tubing Safety Valve is a pressure differentially-operated valve mechanism made up on an OTIS Type B locking device, which can be run on an ordinary wire line and set at any desired depth in the tubing string.

With its automatic valve mechanism manufactured from stainless steel and Monel metals, the FB Safety Valve is *always* in working order — ready to provide an instantaneous and complete subsurface shut-off *when you need it!*

Under normal controlled flowing conditions the valve is held open by a coiled spring, thus allowing a straight, free flow through the tool and the tubing at a predetermined rate. However, the instant surface connections fail or become damaged, and the differential pressure across the tool exceeds the compression of the spring, the valve automatically snaps shut—*in an instant!*— and prevents wild flow.

After surface connections are repaired, the FB Safety Valve automatically re-opens when pressures across it are equal. In wells where injection pressures are not available to equalize across the valve, an OTIS Equalizing Sub can be made up between the locking mandrel and valve mechanism. This provides a means of equalizing pressures through the use of Equalizing Prongs run on a wire line.

***Remember,* if you are operating a flowing well in a critical area, place your trust in an OTIS Safety Valve—instead of trusting your luck!**

OTIS PRESSURE CONTROL EQUIPMENT

OTIS PRESSURE CONTROL, INC.

SALES AND SERVICE . . . DALLAS 9, TEXAS

FIELD OFFICES

TEXAS— HOUSTON, CORPUS CHRISTI, AND LONGVIEW

OKLAHOMA— OKLAHOMA CITY NEW MEXICO— HOBBS

LOUISIANA— NEW IBERIA

MANUFACTURE AND DEVELOPMENT

OTIS ENGINEERING CORPORATION

DALLAS, TEXAS

DISTRIBUTORS

OTIS PRESSURE CONTROL, INC., Bolivar, Texas

OTIS EASTERN SERVICE, INC., Bradford, Pennsylvania

WESTERN PRESSURE CONTROL, Los Angeles, California

Hold operating clinic

A conference unique in American industrial management was held in Pittsburgh recently when the operating heads of the divisions and subsidiaries of Rockwell Manufacturing Company met to coordinate their diversified manufacturing, engineering, research, purchasing, and marketing facilities.

W. F. Rockwell, Jr., vice president and general manager of the Rockwell Manufacturing Company, who conducted the meetings, explained that the expanding peacetime production of the company's widely scattered plants made it difficult for the plant managers to keep fully abreast of the new developments within other plants.

"One of the biggest advantages of a company such as ours is the integration of manufacturing facilities and exchange of manufacturing know-how," Rockwell said. "In this meeting we set aside time for discussion of all management problems our plants have in common—sales, advertising, research, purchasing, industrial relations, accounting, and interplant production.

"Free exchange of information on these problems helps us stabilize employment at the highest level in all plants, lowers manufacturing and distribution costs, expands our markets, and short cuts engineering and research projects. What one plant might otherwise spend thousands of dollars to learn, can be taken from the experience of another unit."

Included among the products of the Rockwell Manufacturing Company are such differing products as meters, valves, and machine tools.

Subsidiaries and divisions represented at the conference included: Pittsburgh Equitable Meter Division, Pittsburgh and Brooklyn; Nordstrom Valve Company, Pittsburgh and Oakland, California; Rockwell Machine Company, Hopewell, New Jersey; The Delta Manufacturing Company, Milwaukee, Wisconsin; the V and O Press Company, Hudson, New York; Edward Valves, Inc., East Chicago, Indiana; The Crescent Machine Company, Leetonia, Ohio; The Monessen Foundry and Machine Company, Monessen, Pennsylvania, and Arcade Manufacturing Division, Freeport, Illinois.

Labor honors management

An outstanding and encouraging event in the field of labor management relations took place recently in St. Louis. The employes of the John Nooter Boiler Works Company honored the management of the concern with a Fiftieth Anniversary Jubilee Banquet, planned and arranged by the Nooter Booster's Club, an employe organization. The banquet was, in a way, the culmination of half a century of cooperation between the executives of the company and the workers in the shops and offices. Since 1895, when John Nooter, a young Dutch immigrant, started his enterprise, the company bearing his name has progressed from a small boiler repair shop to one of the leading steel and alloy plate fabricators.

At the Jubilee Banquet, held in the DeSoto Hotel, three important addresses were delivered. William C. Rand, president of the Monsanto Chemical Company, told of the close relationship between the interests of his company and the Nooter company. He cited the tremendous progress made in industrial fields during the war years. In his closing remarks Rand stated that under the private enterprise system that brought success to John Nooter, progress, individually and collectively, continued to be possible. Such progress, he said, is contingent on cooperation among all factors that enter into the production picture . . . labor, management and government.

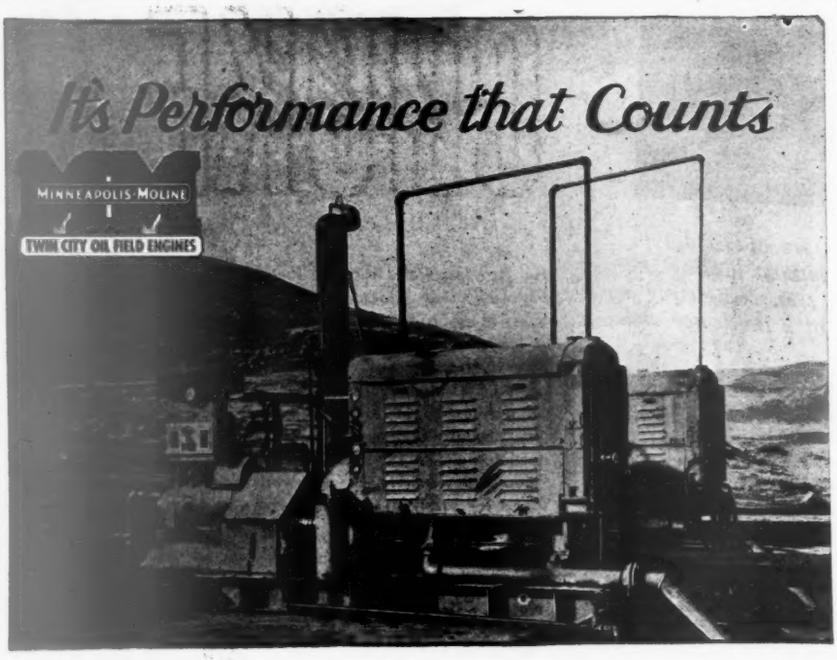
Following Rand, Charles MacGowan, president of the International Brotherhood of Boilermakers, Shipbuilders and Helpers of America, an A F of L organization, spoke in behalf of labor.

Responding in behalf of the management of the John Nooter Boiler Works Company, Robert J. Ryan, vice president and general manager, thanked the employes for this gesture of honor and respect. He outlined the history of the company and stated that he had every confidence that the organization would continue to progress in the years ahead, and that the same harmony between all parts of the company would continue.

Heat treating plant

A new $150,000 heat treating plant has just been built by the H. C. Smith Oil Tool Company, Compton, California, and is now in operation.

The new facilities will enable the company to offer an even more precise and scientifically controlled treatment of the steels used in the manufacture of H. C. Smith rock bits, company officials state.



The *value received* from an oil field engine *is not measured* so much by its *cost* but rather by the *performance* that it gives—an engine that will operate 24 hours per day, day in and day out giving low cost, efficient performance free of mechanical breakdown is the one that *stands out* in the final analysis. *25,000 hours of continuous service* with stops only for oiling and greasing *is not uncommon* with *MM Oil Field Engines*. All the low cost, high performance features are *"built-in"* on *every* MM Oil Field Engine—that is why we say when *you* buy an Oil Field Engine *"It's Performance that Counts"*.

MM Engines are built in 7 sizes to fit most every oil field application:

165-4A . . .	3⅝x4, 4 cyl.		
206-4A . . .	3⅝x5, 4 cyl.	HUA . . .	4⅝x6, 6 cyl.
KUA	4¼x5, 4 cyl.	MEU . . .	8x9, 4 cyl.
LUA	4⅝x6, 4 cyl.	NEU . . .	8x9, 6 cyl.

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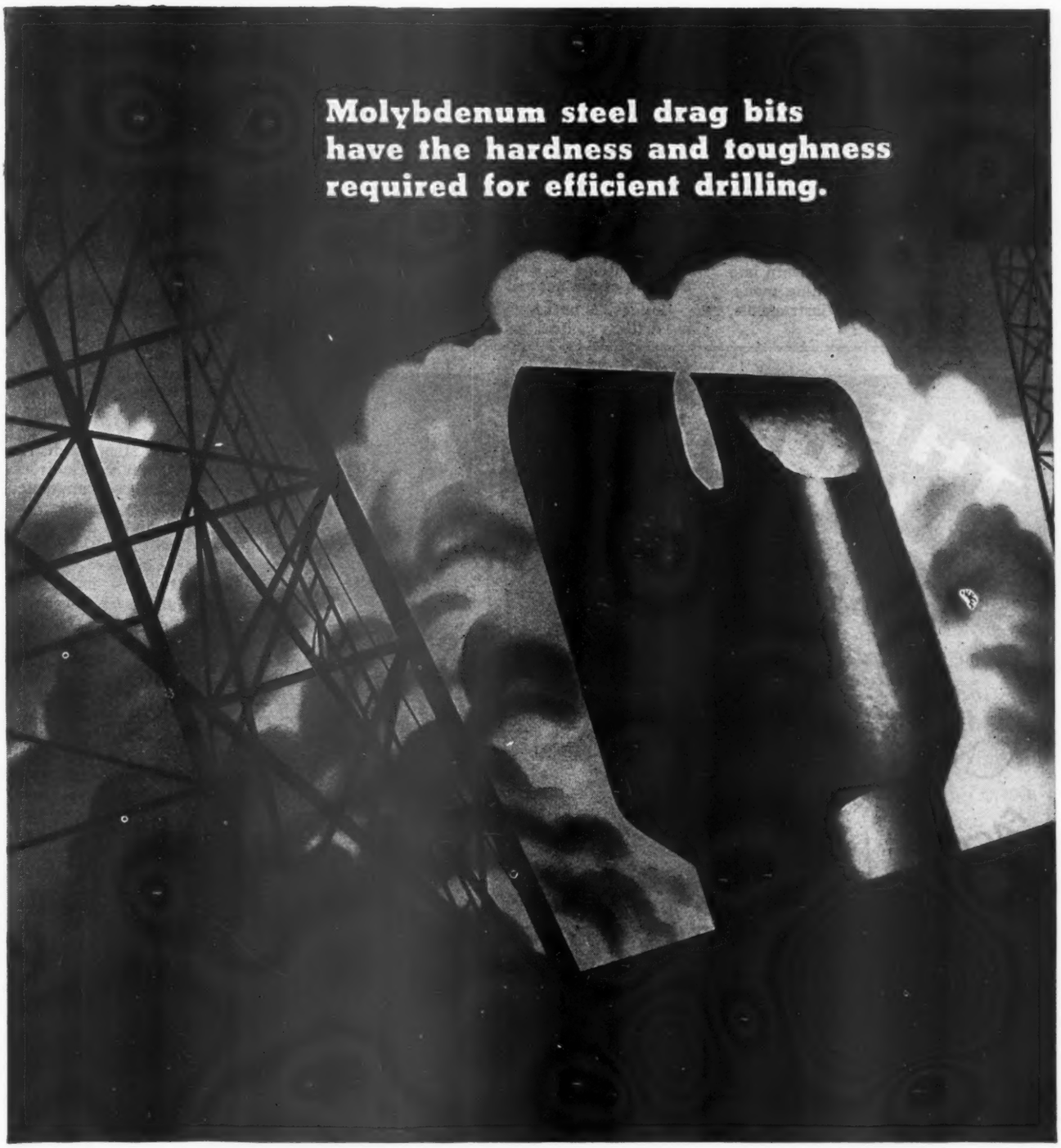

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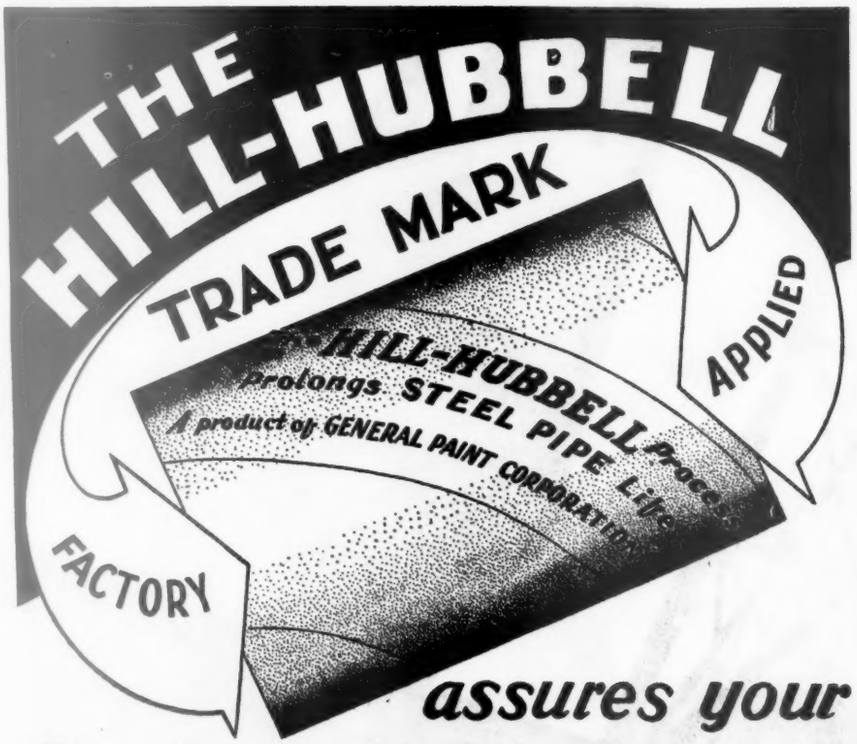
MOLY

Decker sole owner

At a luncheon recently tendered members of the trade press at the Virginia Country Club, Long Beach, California, announcement was made that W. R. "Frosty" Martin had disposed of his interest in the Martin-Decker Corporation. By this move "Frosty" Martin retires from active participation in the company, and E. L. Decker becomes president and sole owner. There will be no change in company name, nor in the policies that have built this concern into one of the country's outstanding manufacturer of drilling control instruments, it is announced.

The formation of the Martin-Decker Corporation 17 years ago brought together two remarkable personalities. "Frosty," scion of a famous pioneer oil family, has been connected with the oil industry 67 years starting as a boy of 8 tending his father's 3 stripper wells in Pennsylvania. He is reputed to be the oldest oilman in California in point of service. In recent years he has acquired newspaper interests and gives much of his time and energy to harbor development. This activity has led to numerous high positions of trust among port authorities of the nation.

Besides his untiring efforts in developing drilling control instruments to lower drilling costs, Elmer Decker is widely known for his broad interest in the welfare of the oil industry and civic affairs. He was founder and first president of the Nomads. He helped organize and is president of Equestrian Trails, Inc., a statewide organization of horsemen, and is a chairman of a committee to further the state bridle trails program. "Deck" is vice president and director of the Long Beach Chamber of Commerce and active in many civic activities.



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"Oilwell" appointments

A number of recent appointments have been announced by Oil Well Supply Company, Dallas, Texas, subsidiary of United States Steel Corporation.

James A. Hill has been named manager of the newly created Colorado-Wyoming district office at Casper, Wyoming.

In charge of the new Montana district office at Great Falls, is A. S. Finefrock.

Ben H. Ravanell has been appointed Rocky Mountain division engineer, and A. D. Otto Rocky Mountain division office manager. Both will have their headquarters at Denver, Colorado.

D. L. Collins is the new manager of machinery sales, Gulf Coast division. J. F. Barling is office manager. Division headquarters are at Houston, Texas.

Appointees in the Mid-Continent division are J. A. Teter, division office manager; G. I. Wyckoff, division engineer, and J. P. O'Toole, manager subsurface department. Division headquarters are at Tulsa, Oklahoma.

Central Midwest division, Dallas, appointments are R. H. Christy, office manager; John S. Fuller, division engineer, and R. T. Shoemaker, manager sub-surface department.

S. T. Lutz has been named manager of the Wichita, Kansas, sales office.

Acquires firm

Acquisition of the entire common stock of Wailes Dove-Hermiston Corporation, of Westfield, New Jersey, by Koppers Company, Inc., of Pittsburgh, is announced in a joint statement issued by J. N. Forker, Koppers vice president, and Linden Stuart, president of the New Jersey company.

Koppers Company, Inc., is a leading designer and builder of coke ovens and manufacturer of byproducts from coal, and Wailes Dove-Hermiston Corporation is a manufacturer and contractor of bituminous coatings for the protection of iron and steel against corrosion. The latter company will continue to operate as a separate organization with the same management that has been in charge of its affairs for many years.

New Bethlehem store

Bethlehem Supply Company announces the opening of its first new store for 1946 at El Dorado, Kansas. F. W. Jensen, who recently joined Bethlehem, is store manager and field representative. R. A. Johnson, district manager for Kansas, has his offices at 523 Union National Bank Building, Wichita.

Every time you Pull the tubing, You take a "Bite out of your Profits"

Many Nixon Gas Lifts have been in service
5 years
without the tubing ever being pulled.

More and more producers are realizing the efficiency and economy of The Nixon Surface Control Gas Lift to lift their oil.

While the cost of the original installation is much lower than other accepted methods—it is in the cost of operation over a lengthy period of time that the Nixon Gas Lift really proves its economy.

One of the chief reasons for this low lifting cost is the long life of trouble free operation—which means that the tubing seldom has to be pulled. It costs good money to pull tubing and replace or repair sucker rods and every dollar so spent means "less profit."

More than 3,500 Nixon Units are now in use—performing satisfactorily.

A recent booklet on the installation—care—and operation of the Nixon Surface Control Gas Lift has been prepared. A copy will be mailed you upon request.

Contact your nearest Wilson Supply Co. store or write

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SALES OFFICES: Tulsa, Oklahoma; Dallas and San Antonio, Texas. LOS ANGELES: Western Pressure Control, 5700 Santa Fe Avenue. TRINIDAD, B.W.I.: Neal Massey Eng. Corp.

BRANCH STORES: TEXAS—Kilgore, Beaumont, Barbers Hill, Bay City, Monahans, Alice, Victoria, Corpus Christi, Columbus. LOUISIANA—Lake Charles, New Iberia, Harvey, Shreveport. ARKANSAS—Magnolia. MISSISSIPPI—Natchez.

Association officers

E. J. Schwanhausser, vice president of Worthington Pump and Machinery Corporation, was elected president of the Diesel Engine Manufacturers Association at the association's annual meeting.

Gordon Lefebvre, president of Cooper-Bessemer Corporation, and J. E. Peterson, vice-president of General Machinery Corporation, were elected vice presidents.

Reelected as treasurer was Robert H. Morse, Jr., vice president and general sales manager of Fairbanks, Morse and Company.

Harvey T. Hill, executive director of the association, likewise was reelected to serve through 1946.

New directors elected are A. W. McKinney, vice president of National Supply Company; G. F. Twist, vice president and general manager of Atlas Imperial Diesel Engine Company, and Norris H. Schwenk, president of Busch-Sulzer Bros.-Diesel Engine Company.

Continuing on the board of directors are George W. Codrington, vice president of General Motors Corporation; Charles E. Brinley, chairman of the board, Baldwin Locomotive Works; Robert E. Friend, president of Nordberg Manufacturing Company; Schwanhausser, Morse, and Lefebvre.

Gas measurement course

The general committee of the Southwestern Gas Measurement Short Course has set April 23, 24, and 25, as dates for the 1946 School to be held at the University of Oklahoma, Norman, Oklahoma.

Other business of the meeting, which was held in Dallas, Texas, recently, included the election of committee chairmen and action on recommendations of the executive committee. Committee chairmen elected were as follows: Program committee, R. M. Scofield, Lone Star Gas Company, Dallas; publications committee, C. E. Terrell, Southern Natural Gas Company, Birmingham; exhibits committee, J. L. Griffin, Northern Natural Gas Company, Omaha; registration and publicity committee, Miss Kate A. Niblack, Oklahoma Utilities Association, Oklahoma City; local arrangements committee, W. H. Carson, Norman, Oklahoma. W. H. Woods, Gulf Oil Corporation, Houston, is to continue to serve as chairman of the practical methods committee for another year.

South American branch

Establishment of a branch office in Caracas, Venezuela, to serve expanding markets in that country, Colombia and Peru, is announced by M. C. Pollock, vice president in charge of export sales for The Cooper-Bessemer Corporation, with plants at Mount Vernon, Ohio, and Grove City, Pennsylvania.

A survey of South American markets completed recently by Pollock indicated a growing demand there for diesel engines and engine-driven compressors.

Well logging conference

A conference on well logging methods, sponsored by the Petroleum Engineering Department, will be held in the Petroleum Engineering Building at Texas A. and M. College, from Monday, March 11, at 1:30 p.m., through Friday, March 15, at 5:00 p.m. This conference will cover all types of well logging.

Hubert Guyod, well logging consultant and graduate of the School of Mines, St. Etienne, France, will lead the conference. Guyod served as chief engineer for Schlumberger from 1935 through 1940, and as research engineer for Halliburton from 1940 through 1945.

The Halliburton Oil Well Cementing Company, Baroid Sales Division National Lead Company, Lane-Wells Company, Schlumberger Well Surveying Corporation, Horvitz Laboratories, and Dowell Incorporated are cooperating, and will give field demonstrations.

The conference is open to all interested parties.

Thomas E. Kraner has been appointed branch manager in charge of the new South American headquarters. Kraner, a graduate of Purdue University, has been affiliated with Cooper-Bessemer since 1937 and has been with its Washington office for the last 6 years.

Kraner has already assumed his duties at the South American office.

A. E. Welch promoted

R. C. Walker, president of Aireon Manufacturing Corporation, has announced the election of Arthur E. Welch to fill the newly created important postwar office of vice president in charge of sales.

Welch was formerly vice president and treasurer. He brings to this new key position keen understanding of Aireon's numerous activities, its policies, postwar plans, and sales activities.

Following his affiliation with Aireon in 1944, as controller of the Kansas City division, Welch's ability was quickly recognized and he advanced rapidly through various executive positions. His wartime service included the audit section of the U. S. Army Air Forces as resident auditor at the Buffalo, New York, plant of Curtiss-Wright.

Sales representative

Stuart E. Corry has been appointed sales representative of the Franks Manufacturing Corporation of Tulsa in the states of Illinois, Indiana, Michigan, and the western part of Kentucky. Corry will maintain his representative office at Fairfield, Illinois, box 51.

Stuart E. Corry

Corry joined the Franks organization in August, 1943, with an extensive experience in the engineering field, having come directly from the Spartan Aircraft Company where he held the position of chief tool engineer.

Pioneers' party

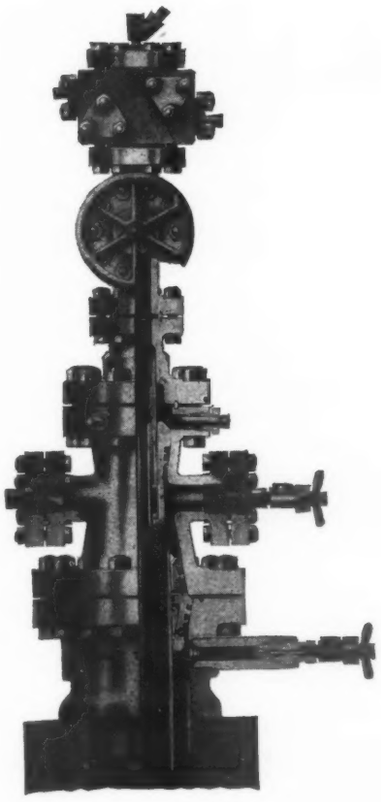
The Petroleum Production Pioneers held a 1946 Spudding-In party in the Ballroom of the Los Angeles Elks Club recently at which 250 members and friends enjoyed a steak dinner that was reminiscent of prewar days, exchanged pioneer stories to the seven signs of the zodiac, and enjoyed a really swell vaudeville show arranged by that great booking agent, Ernie Fowks. The get-together began at 5:30 p.m. and in addition to the aforementioned list of events, featured the installation and presentation of new officers. It was unfortunate that Henry Grinnell, president of the organization, couldn't be there. He was laid low with a bad attack of flu that later blossomed into pneumonia (he is now fully recovered), but he was voted the unanimous good wishes of the assembly and an able deputy in the person of Lou Bronzan, vice president, was there to take over the presidential chores, which he did with full competence. Each of the new officers as he was introduced gave a brief outline of his plans for the coming year and there was throughout an unmistakable enthusiasm, not alone over progress to date but also over the future of the organization.

The officers who will be responsible for the conduct of affairs in 1946 are as follows: President, J. E. Gosline, Standard Oil Company of California; vice president, L. George Trembley, Howard Supply Company; honorary president, F. F. Hill, retired, former Union Oil Company; honorary vice president, W. R. Guiberson, W. R. Guiberson Company; secretary, R. Sneddon, Pacific Coast editor *The Petroleum Engineer;* treasurer, C. S. Perkins, Union Oil Company; assistant secretary, T. A. Atkinson, General Petroleum Corporation; assistant treasurer, E. W. Webb, Continental Oil Company; sergeant-at-arms, B. Bronzan, Baash-Ross Tool Company; assistant sergeant-at-arms, E. B. Fowks, Emsco; historian, Ted Sutter, Baker Oil Tools, Inc.; publicity chairman, H. H. Roberts, Standard Oil Company of California.

Immediately after the introduction of the new officers, Ernie Fowks presented Eddie Bartell, one of Hollywood's best mimics, one of the famous radio rogues, who M.C.'d the excellent vaudeville show that followed and gave a fine performance himself.

As usual, however, the really exciting part of the evening's entertainment was the opportunity to wander around greeting old friends and exchanging yarns of yesterday. It is the hope of Ted Sutter that these yarns and the colorful lives of the men who tell them will one day be incorporated into an authentic and complete historical record of the California petroleum industry. That is one of the very worthwhile projects of the Pioneers' organization. It has already been under way for some time, and plans are now being made to expand the activity so that before another year has passed progress should be well advanced.

SIMPLICITY is the first requisite of well control



The better design accomplishes its purpose with fewer, rather than more parts

Because simplicity, the fewest number of the highest quality parts, is the first requisite of well control, this means taking from, rather than adding to equipment. The organization which actually succeeds in finding a solution to the problem of well control must concentrate its efforts on the development of control, rather than on the sale of equipment. As it sells less equipment while performing the job with safety and efficiency, its contributions and service are of greater value.

For example, certain packers, equipment used for control, actually result in well control *without control* until coordinated with other control equipment to permit their installation with control. Blowout preventers, master valves, tubing and casing hangers, seals, etc., essential equipment for use in well control, result in well control *without control* until coordinated to permit their assembly and use with control throughout their entire period of usefulness, and their disassembly with control upon completion of their operating function.

Only by such coordination can simplification, the fewest number of the highest quality parts, become a reality. Only through this process of elimination, the ability to assemble and disassemble the equipment with control, can a solution to the providing of well control with control be found. There is no gap in control when you use Gray Systems of Well Control.

The whole is greater than any of its parts. The better design accomplishes its purpose with fewer, rather than more parts.

GRAY
TOOL COMPANY
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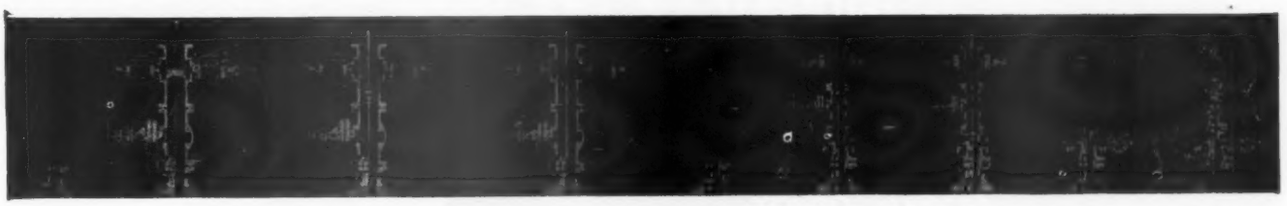
Export Representative: GUY E. DANIELS, 30 Rockefeller Plaza, New York City

CONTROL DURING AND BETWEEN ALL OPERATIONS WITH GRAY PLANNED PROCEDURE



Casing Head Attached | Drilling | Running Casing | Casing Landed | Drilling Control Equipment Removed | Drilling-in and Running Tubing | Tubing Landed | Control Equipment Removed | Manifold Attached

A.P.I. meeting

The regular spring meeting of the American Petroleum Institute, Production Division, will be held at the Los Angeles Biltmore Hotel on April 11 and 12, according to announcement by Basil P. Kantzer, chairman of the Pacific Coast district.

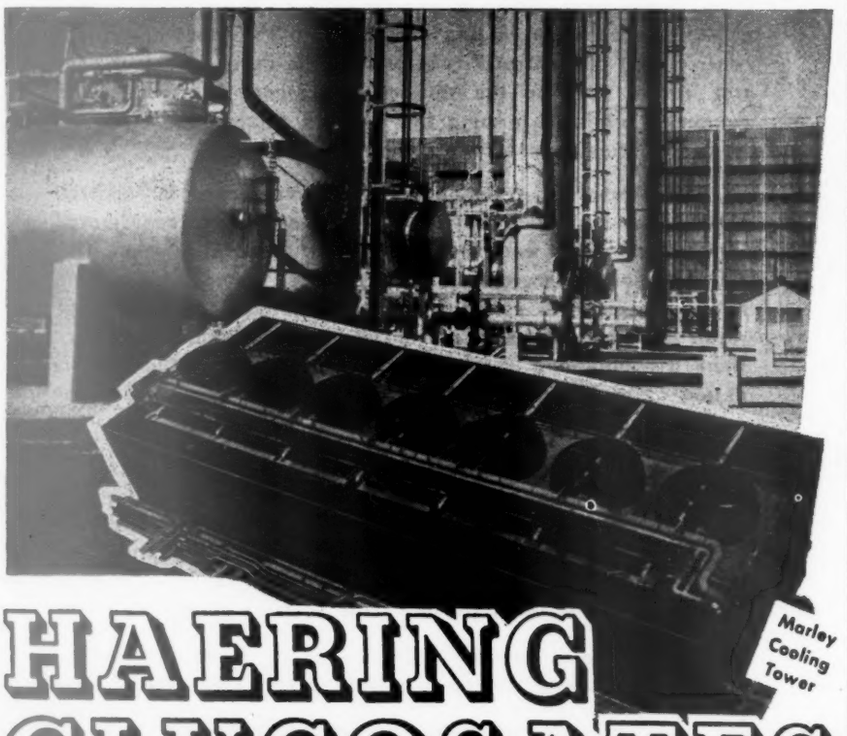
The production sessions will be geared to the general topic of results obtained by injection of water and gas into California fields, with particular emphasis on the operating problems encountered and the solution that was developed. The drilling sessions will be keyed to well completion practices, with emphasis on economics and results obtained.

Committees in charge of the meeting are: Chairman, Pacific Coast district, Basil P. Kantzer, Union Oil Company. Chairman of program committee, M. W. Morris, Standard of California.

Drilling session: Chairman, Lot Bowen, Western Gulf Oil Company; vice chairman, J. O. Hills, General Petroleum Corporation; Dean Sheldon, consultant; Gene Davis, Signal Oil and Gas Company; Joe Jensen, Tide Water Associated Oil Company; W. J. Travers, Richfield Oil Corporation; Ed Foss, Barnsdall Oil Company, and Ed Webb, Continental Oil Company.

Production practice session: Chairman, E. V. Watts, General Petroleum Corporation; vice chairman, P. L. Kartzke, Shell Oil Company; E. W. McAllister, Western Gulf Oil Company; E. K. Parks; J. E. Sherborne, Union Oil Company; M. B. Standing, Standard of California; W. R. Wardner, Jr., Conservation Committee of California, Oil Producers, and Read Winterburn, Union Pacific Railroad.

General arrangements: E. A. Pellegrin, chairman, Macco Construction Company. Hotel arrangements, chairman, W. L. Heater, Baroid Sales, Division of National Lead Company. Banquet sales, C. T. Reichert, chairman, National Supply Comany. Finance, chairman, K. F. Forsyth, Emsco Derrick and Equipment Company.



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To aid China refining

Gustav Egloff

W. B. Shanley

Universal Oil Products Company is to play an important part in the establishment and development of a modern petroleum refining industry in the Republic of China, under the terms of an agreement between Universal and the National Resources Commission of China.

The National Resources Commission of China is charged with the duty of promoting, developing, and controlling the key industries and to administer other industrial enterprises as assigned by the government. The commission is now operating approximately 100 enterprises including about 30 mines and 30 power plants and 40 manufacturing plants in China.

The heads of the National Resources Commission of China are Dr. Wong Wen Hao and C. C. Chien. They maintain an office in the United States at 111 Broadway, New York 6, New York. C. Yun is the director and Dr. K. C. Sun, deputy director. Dr. C. D. Shiah is a member in charge of petroleum and chemical projects.

Two Universal engineers, Dr. Gustav Egloff and W. B. Shanley, will soon leave by air for China to make a preliminary study and to recommend steps to be taken to:

(a) Improve the operations of refineries now running.

(b) Place in operation refineries now operable.

(c) Effect repairs, replacements, and modifications required to place damaged refineries in service.

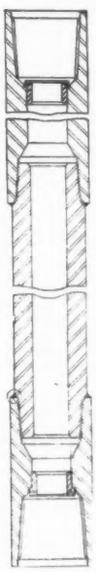
(d) Coordinate and expand refining facilities for present and future regional and national needs of China.

New and Improved MACHIN IPMENT

A REGULAR FEATURE
appearing in
THE PETROLEUM ENGINEER
700 Irwin-Keasler Bldg.
Dallas 1, Texas

(1) *Drill collar rental*

Sperry-Sun Well Surveying Company has recently added to its line of well surveying instruments and services a new service, the S-S non-magnetic drill collar rental.



The use of this drill collar permits the taking of directional single shot records inside the drill pipe. There is no need to remove the drill pipe from the hole or to raise the drill string to allow the instrument to dangle through a specially designed, but ineffiient, bit.

The S-S non-magnetic drill collar is placed immediately above the regular bit and the non-magnetic section carries the directional single shot instrument and protects it against both loss and damage. The records obtained are more accurate because the instrument, being seated inside of the drill collar, is always parallel to its walls, it is asserted.

The non-magnetic sections of the S-S drill collar are made of "K" Monel metal.

A cross-section of the S-S drill collar is shown herewith. It will be noted that the tool joints are made of steel and are welded to the "K" Monel metal section by a special welding process.

Extensive field tests made with the non-magnetic drill collar have demonstrated that by its use directional single shot records can be obtained at a great saving of rig time, that the records obtained are accurate, and the operation of the single shot instrument is less hazardous, according to Sperry-Sun officials. The use of the S-S non-magnetic drill collar is particularly advantageous in directional drilling in which the reaching of the sub-surface objective with the least deviation and with the greatest saving of rig time counts.

The S-S non-magnetic drill collars are made in standard sizes. At the present time there are available for rental at the company's Houston, Texas, and Long Beach, California, offices, drill collars of 6 in. O. D. and 6¾-in. O. D. Additional sizes will be made available in the near future.

Keep Posted On
NEW EQUIPMENT
Use Card

Advancements in petroleum and plant equipment are being made rapidly. Keep abreast by making full use of *The Petroleum Engineer's* enlarged New Equipment Section.

All items are numbered. A business reply card requiring no postage if mailed within the United States is provided. Check or encircle the number on the card that corresponds with the product or products in which you are interested and drop it in the mail. Literature and prices will be sent promptly on receipt of card.

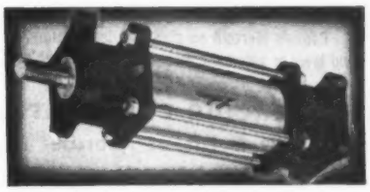
(2) *Pumping control*

Combining circuit protection and motor control in a single unit to save space and wiring, a new a-c. magnetic oil field pumping control is announced by the Westinghouse Electric Corporation.

The new unit is especially designed to provide for the automatic starting and stopping of oil field pumping motors. Weatherproof enclosure permits outdoor pole mounting close to the load. The dead front inner door protects the operator from live parts when cabinet door is opened.

The starters are available in two basic types, each providing overload and low voltage protection. The automatic unit includes AB breaker, "De-ion" linestarter, lightning arrester, hand reset low voltage relay, "Hand-Off-Automatic" selector switch to permit manual operation, socket and time switch. The time switch automatically controls specific pumping periods during the day. The local control unit includes AB breaker, "De-ion" linestarter, lightning arrester, and start-stop pushbutton. Ratings are from 1 to 25 hp., 110, 220, 440-600 volts.

(3) *Cylinders standardized*



Advancement in design and construction of cylinders is announced by the Engineering Products Company, Los Angeles, California. Cylinders in the past have been built in a number of types, models, sizes, and an infinite variety of lengths. For the first time in the history of cylinder construction, a standardized cylinder has been produced for operation by air, oil, or water, which lends itself to almost universal mounting applications, the manufacturer asserts. At the same time, the cylinder is completely standardized, is manufactured in quantities, and is available off the shelf is an assortment of diameters, and stroke lengths that meet practically all requirements, it is asserted.

DA Pressure Control

NOTE THE FEATURES

MERCURY SWITCH
Hermetically sealed mercury switch is used. They cannot be affected by dust, dirt or corrosion; nor are they subject to open arcing, oxidation, pitting or sticking of contacts, all common causes of contact trouble. This switch will give better control service and longer control life.

BOURDON TUBE
(Hidden back of cover)
The Bourdon tube is the actuating element of the control. It is the oldest known, tried and proven element, having been used in gauges for many years.

OUTSIDE ADJUSTMENT
The outside double adjustment with the calibrated dial and pointers is a convenient feature, making it very easy to set the required operating range, plainly visible on the dial. All guesswork is eliminated.

GLASS FACE
The glass face on the cover permits seeing the entire operation of the control in plain view. One can always tell whether the switch circuit is open or closed, a great convenience whenever servicing becomes necessary.

Consult Mercoid on pressure, temperature, liquid level or automatic mechanical control problems.

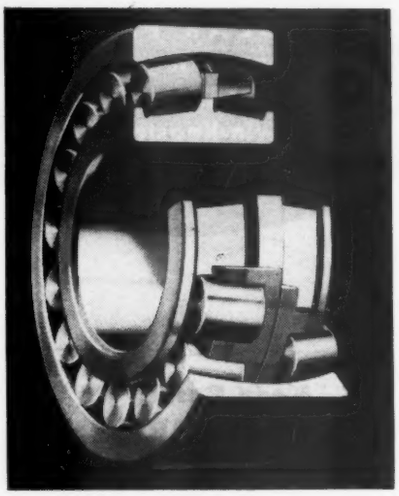
THE MERCOID CORPORATION
4201 Belmont Avenue
Chicago 41, Illinois

THE ASSURANCE OF DEPENDABLE SERVICE BUILT IN EVERY MERCOID CONTROL

(4) *Spherical bearing*

The Bantam Bearings Division of the Torrington Company, South Bend, Indiana, announces the production of a self-aligning spherical roller bearing. This a new addition to its line of antifriction bearings, which already includes straight roller, tapered roller, needle, and ball.

This new spherical roller bearing is specifically adaptable to heavy-duty performance in a wide range of equipment. Of particular interest are the varied applications to machinery used in paper mills, steel mills, oil production, mines, and quarries.



In addition to the self-aligning feature, this new self-aligning Torrington bearing offers (1) two-directional thrust, (2) high radial capacity, (3) high thrust capacity, and (4) unit construction for easy installation.

The new bearing will be produced in a full range of sizes from 1.5748-in. bore upward. It is fully described in Bulletin 100A.

(6) *Indicating flow meter*

The Hays Corporation, Michigan City, Indiana, announces the Hays Veriflow Meter for measuring, indicating, and totalizing various liquids used in industry. The outstanding feature of the new meter is its ability to indicate the rate of flow at a point remote from where the meter is installed. This is in addition to the rate of flow indication and integrator that are integral with the meter itself. To procure the remote indication the generator is mounted on top of the flow meter, the same shaft operating both the generator and the totalizing register. No external source of electricity is required because the indicating meter measures the output of the generator and is calibrated to indicate the corresponding rate of liquid flow through the meter. The scale of the indicator can be calibrated to read in any values of flow desired such as gallons per minute.

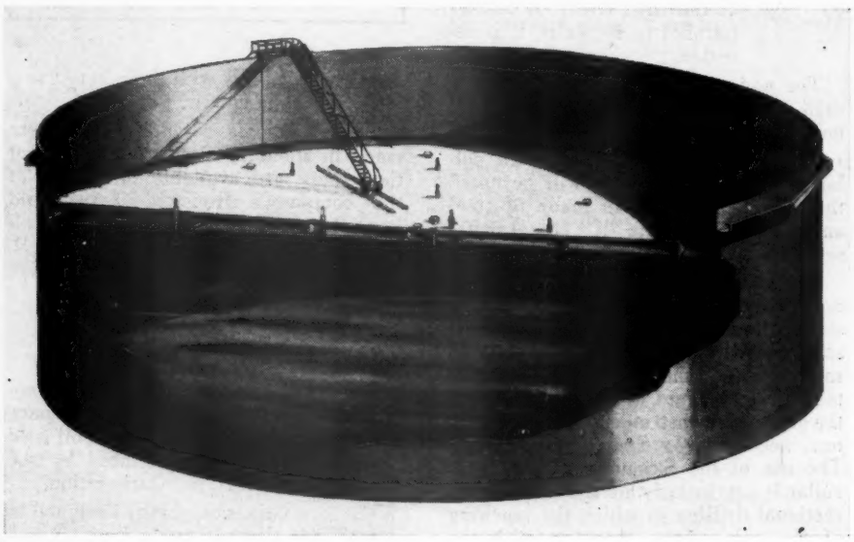
(5) *Horton floating roof*

An improved Horton Floating Roof, of double-deck construction, has been developed by the Chicago Bridge and Iron Company, Chicago, Illinois. It is used on flat-bottom tanks storing volatile liquids.

The double-deck construction insulates the liquid and eliminates practically all boiling, thus extending the range of products previously stored in floating roof tanks.

The bottom of the deck is sloped upward toward the center and the roof is designed to vent all air from beneath the deck. The top of the deck is smooth and slopes toward the drain situated at the center.

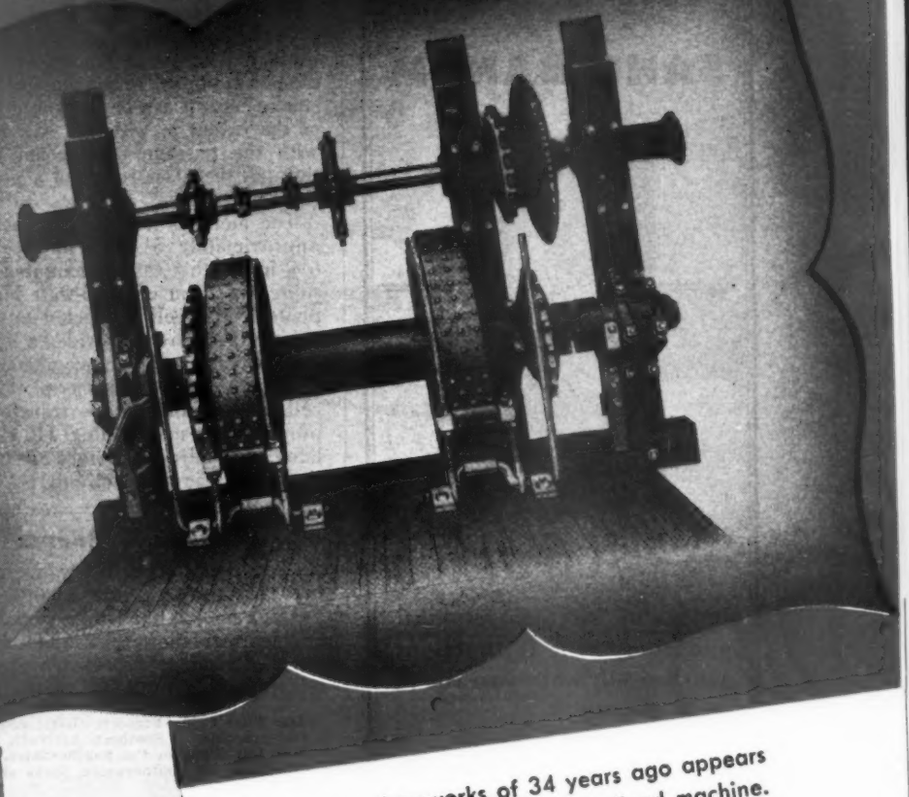
The Horton seal closes the space between the tank shell and the deck. A sealing ring forms a long sliding contact with the tank shell and is joined to the deck by a continuous gastight curtain.

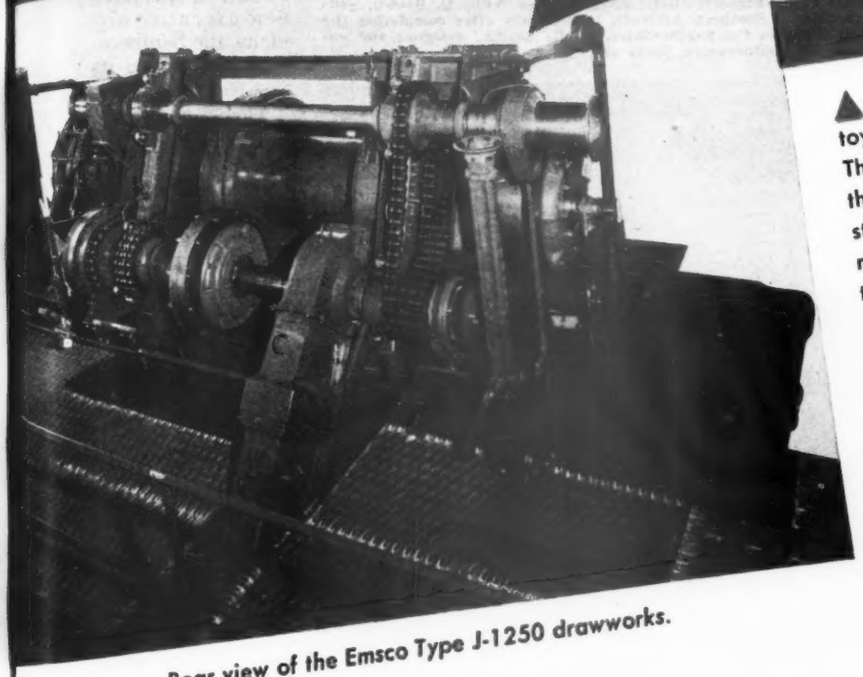


Cutaway view of improved Horton Floating Roof.

1912
when Continental was Founded . . .

YOUR ROTARY DRAWWORKS LOOKED LIKE THIS →





Rear view of the Emsco Type J-1250 drawworks.

▲ A rotary drawworks of 34 years ago appears toylike compared to today's streamlined machine. This is but one of several graphic examples of how the drilling equipment manufacturers have constantly improved their products . . . the improvements that have made possible the efficient exploration for oil.

▲ Continental, since it began serving the oil and gas industries in 1912, has enjoyed steady and well grounded growth. Throughout the world the "green triangle" is a sign of both good equipment and dependable service.

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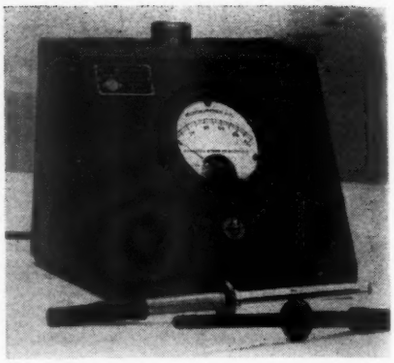
(7) *Smoke meter*

The R. S. Smoke Meter is built to the specifications of the Institute of Cooking and Heating Appliance Manufacturers. In principle this instrument is a photoelectric soot density comparator.

The principle of operation is based on the fact that a pyrex glass rod placed across a stream of flue gas containing oil smoke will collect a deposit of soot on the surface of the rod that will be a function of the proportion of smoke in the flue gas when exposed under specified conditions. The amount of the smoke deposit can be measured in terms of the extent to which it will interfere with the passage of a beam of light through the glass rod onto a photoelectric cell.

The meter is housed in a metal case approximately 5½ in. by 5½ in. by 6½ in. In this case is mounted a light source in form of a 15-watt lamp and photoelectric cell connected to an electric meter. There is provided a light tube for supporting the pyrex glass rod between the lamp and the photoelectric cell. A constant voltage transformer is provided for maintaining 110-v. on the lamp. Two adjusting knobs are provided in the electric meter circuit.



In operation the smoke meter is adjusted for "zero" reading with a dull black rod in the light tube. Then the meter is adjusted for "100" reading with a clean pyrex glass rod in the light tube. After the pyrex rod has been exposed to the flue gases it is replaced in the light tube and the meter will give a reading indicating the per cent light transmitted.

The Refinery Supply Company, Tulsa, Oklahoma, and Houston, Texas, is the manufacturer.

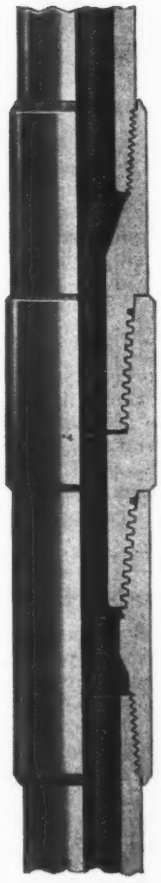
(8) *Southern Aircraft's new plane passes test*

Recently, while a heavy overcast lay over Hudson Airport, outside Dallas, Texas, a smooth-lined, high-winged, twin-engined airplane circled and came to a graceful landing before company officials, including Willis C. Brown, general manager of Southern Aircraft, Chief Engineer A. R. Lardin, and a selected group of spectators. Test Pilot C. T. Prescott taxied back to the crowd and held pp his hand, making a circle with his thumb and finger to indicate complete approval. Southern Aircraft's new executive airplane, the Southernaire, had passed its first test.

Test Pilot C. T. Prescott (left), congratulates Willis C. Brown, general manager of Southern Aircraft, immediately after completing the first test flight in the Southernaire. A. R. Lardin, designer and engineer of the Southernaire, looks on.

The Southernaire, designed and built as a corporation airplane, seating 6 people, carrying 200 lb. of baggage, combines luxury and engineering skill with unusual stability, speed, and cruising radius.

For the last few weeks the Southernaire has successfully undergone extensive flight testing, and is now ready for a tour of the United States. This tour will continue into April, touching at major cities in response to many inquiries that have already come in to the management of Southern Aircraft. By April the Southernaire will be in full production, and delivery schedules are set for that month.



S CONVENTIONAL TOOL JOINT WITH WEAR SUB COSTS **25% MORE** THAN HYDRIL •OS "TWINPIN"— A COMBINATION DRILL PIPE CONNECTOR AND WEAR SUB.

A.P.I. or Hydril Thread

EVEN WITHOUT A WEAR SUB, S TOOL JOINT COSTS TIMES AS MUCH AS RE-SHEATHED HYDRIL "TWINPIN"

But savings in cost are only part of the story. Consider these *other* advantages of Hydril "Twinpins": Easy to exchange or reverse, right on the job, with the regular rig tongs: Since every thread is a make-up thread, it's easy to reverse any joint for distribution of thread wear, tong wear and slip cut: When coming out, the entire string is easily reversed for moving to a new location... all of which contribute to a flexibility in drill pipe handling impossible with conventional tool joints. * OS means oversize.

HYDRIL "TWIN-PIN" OVERSIZE CONNECTORS GIVE LONGER DRILL PIPE LIFE

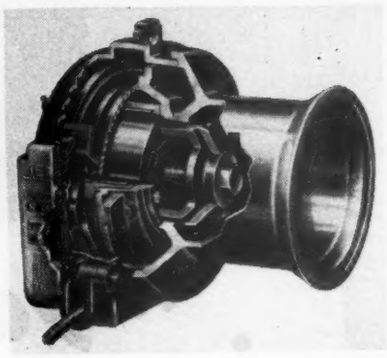
HYDRIL

HYDRIL COMPANY • 714 WEST OLYMPIC BLVD • LOS ANGELES 15, CALIF.

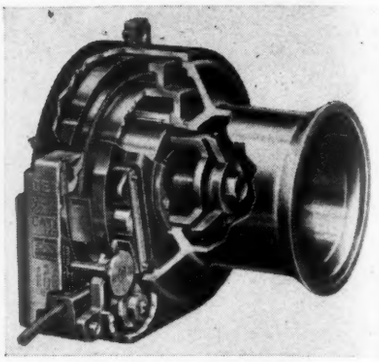
(9) *Catheads*

Gemco Oil Tools, St. Louis, Missouri, has recently developed and is now in production on a complete line of new and improved breakout and spinning catheads. The line consists of a super automatic positive clutch type breakout cathead, a plain automatic positive clutch type breakout cathead, and a (3 in 1) friction clutch type breakout, spinning, and combination make and break cathead, and features many scientific engineering developments.

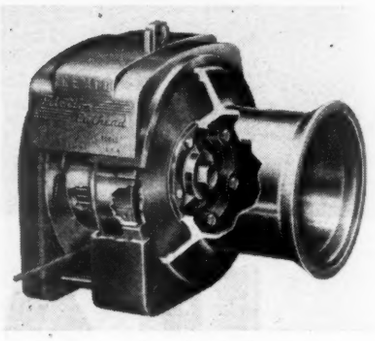
Each of the 3 different types is built around a common base assembly consisting of shaft adapter for adapting to any size or type lineshaft, adapter retainer, roller bearings and spool. On this base assembly may be mounted any of the different cathead units thus permitting complete interchangeability of all types. The base assembly is also a complete unit within itself and may be used independently without the cathead unit when doing work requiring only a spool.



Plain automatic breakout.



Super automatic breakout.



3 in 1 friction breakout and spinning cathead.

Installation has been simplified by the use of a standard anchor for all models. Quick, accurate location is now possible by means of a simple fixture. The anchor also serves as a mounting for optional hydraulic, pneumatic, steam, or mechanical operating control. The cathead may be removed from lineshaft without disturbing either the anchor or operating controls.

(10) *Diesel-driven welder*

A new diesel-engine-driven welder of 300 amp. capacity specially made for use in locations where electric power is not available, or not economical, is announced by the Lincoln Electric Company, Cleveland, Ohio.

Powered by a 2 cycle diesel engine, this addition to the Lincoln "Shield-Arc" welder line cuts fuel costs up to 86 per cent, depending upon the price of fuel oil used, it is stated. In many cases, total savings, including such items as transportation of fuel, losses, etc., are as high as 40 cents per hr.

Engine features include a simplified fuel arrangement with complete fuel filtering system, and many other special features that contribute to the efficiency and service economy of the engine.

Equipped with dual continuous control, this Lincoln welder permits the operator to select any type of arc and any arc intensity to suit the job. This

SIMPLICITY
Is The Secret of the Success of the
MARTIN PLUNGER

Numerous parts (often light and frail) are eliminated when you use the one-piece Martin body.

Greater Strength is obtained.
Greater Durability is obtained.
Greater Accuracy is obtained.

AND . . . we go still further and give you a better ring, compensated to give greater uniformity in the working fit and, therefore, much longer pump runs.

3¾" x 3½ Groove Martin Plunger Body Without Rings

Write for Illustrated Catalog . . . or
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- ✓ HANDLES EASILY
- ✓ RIGS SPEEDILY
- ✓ RUNS SMOOTHLY UNDER ANY LOAD
- ✓ RESISTS FATIGUE AND ABRASION

TIGER BRAND'S ADVANTAGES MEAN...

better drilling, longer line life

WHAT are your rotary line requirements? Do you want lines that are easy to handle? Do you want lines you can install in a hurry . . . that require less breaking in? Do you want lines that behave well under any load . . . at any speed? Do you want lines that stand up under long, hard service . . . that are easy on your equipment? Then, consider these widely recognized advantages of TIGER BRAND:

U·S·S American TIGER BRAND Rotary Lines are made of high tensile wire from Monitor Improved Plow Steel. Their Excellay Preformed construction means that each wire and strand in the line will carry its proportionate share of the load.

These superior lines are extra tough, extra flexible. They have less tendency to loop or kink when you reave them by hand. They hug the sheaves and drums at all speeds. They are highly resistant to bending fatigue and abrasion.

These factors helped make TIGER BRAND the best known Rotary Lines in the industry. They will help you do a more efficient job of drilling. They will reduce maintenance and line replacement costs. For these reasons, it will pay you to keep in touch with your U·S·S American TIGER BRAND distributor.

Excellay Preformed

UNITED STATES STEEL Presents The THEATRE GUILD On The AIR Every SUNDAY EVENING AMERICAN Network (Blue)

AMERICAN STEEL & WIRE COMPANY
Cleveland, Chicago and New York
COLUMBIA STEEL COMPANY
San Francisco
United States Steel Export Company, New York
UNITED STATES STEEL

U·S·S AMERICAN TIGER BRAND WIRE ROPE — UNITED STATES STEEL

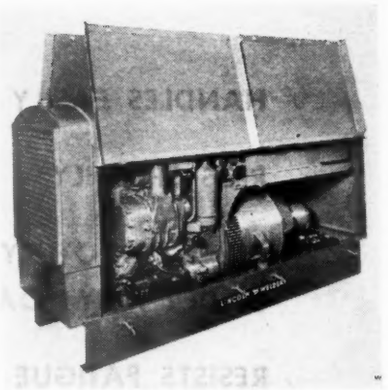
U·S·S AMERICAN
TIGER BRAND *Wire Rope*

feature improves the speed, quality, and ease of welding. Also, because of its fine adjustment, it makes possible a much wider range of application—both as to thickness and classes of metals and alloys. Other features of the welding generator include separate excitation and laminated magnetic circuit for a smoother, more productive arc at all current values.

The welding generator has NEMA rating, 300 amp. at 40 volts. Current range for welding duty is from 20 to 40 volts, 60 to 375 amp. It is of the single operator variable voltage type, with complete magnetic circuit (frame and pole pieces) and is equipped with interpoles. No external reactance or stabilizer is required. Patented dual control of welding current is accomplished by adjustment of both series and shunt fields. Uniform welding current is supplied for metallic arc welding in any position with bare or heavily coated electrodes, also for carbon arc welding.

The generator control can be adjusted in continuous sequence of fine steps by means of shunt field rheostat. Current can be adjusted independently of open circuit voltage in continuous sequence of fine steps by means of series field current control. Combination of these controls permits operator to select any type of arc and any arc intensity to suit the job.

All control parts are contained in a steel cabinet. No current carrying parts are exposed. Voltage and current controls, and polarity reversing switch, are mounted on the "dead-front" panel of the control cabinet. Positive snap action polarity reversing switch indicates polarity on dial.



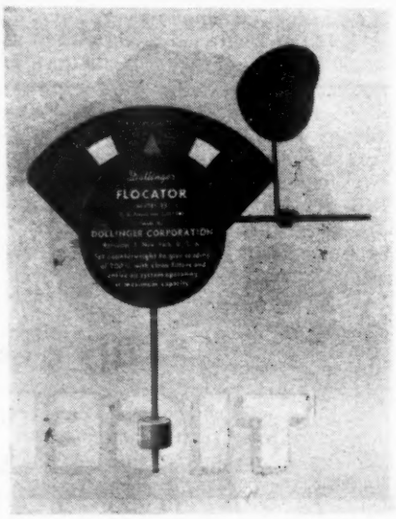
Exciter and main welding generator are electrically separate to improve welding performance and reduce upkeep costs. Exciter is direct connected on commutator end of generator armature. Exciter armature is mounted by sleeve construction on the same shaft as the generator armature.

The new "Shield-Arc," 300-amp. welder (stationary model) weighs 2560 lb. and can be readily mounted on wheels, trailer, or truck for easy portability. Optional equipment includes spring mounted running gear of automobile trailer type with four wheel pneumatic tires.

(11) *Dollinger flocator*

Now in production at the Dollinger Corporation, Rochester, New York, is the Dollinger Flocator, the latest design of a new and inexpensive air flow indicating instrument. It was designed for use in any air ventilating system.

The Flocator is scientifically constructed and will require little or no attention for continuous operation, it is asserted. According to the manufac-



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NARROW TYPE
TRAVELING BLOCK

15,000 FEET PLUS

The 104" Narrow Type Traveling Block is offered in 4, 5, or 6-sheave models, designed to carry any loads encountered in the deepest wells. The narrowness, compactness and streamlining provide many advantages.

DEEP WELL CHAMPIONS

In recent years all record-breaking deep wells have been equipped with Regan Crown and Traveling Blocks.

For full information write for new bulletins

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LARKIN *Geyser Shoe*

PERFECT *Circle* CEMENTING

Since "Perfect Circle Cementing" was introduced as another Larkin contribution toward cementing equipment perfection, operators all over the world have tested it under the most difficult conditions They have pronounced it a great achievement!

And it is the most advanced method in side-action cementing shoes. It efficiently and safely performs the three paramount functions of floating equipment.

- **It washes the well bore clean wherever fluid action contacts it**
- **It distributes slurry evenly at shoe point**
- **It provides a safe float and rugged guide for the longest casing string**

Check with your supply store. They have a complete line of Larkin Cementing equipment.

PROVED A *Great Achievement* BY WORLD WIDE PERFORMANCE

LARKIN

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WAREHOUSES Houston, Corpus Christi, Odessa, Shreveport, Tulsa, Great Bend, Wichita Falls
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Perfect Circle Cementing in action! The Larkin Geyser Shoe incorporates all the desirable features obtainable in side-action cementing equipment

turer, it supplies information that the ordinary type of draft gage fails to indicate; namely, the percentage of maximum flow being obtained at all times.

The Flocator will warn against any loss of air flow in a ventilating system from any cause whatsoever, thus preventing circulation loss that will in turn lower operating costs. It is being manufactured in two models, Model 45 for small capacity ventilation, and Model 75 for large capacity systems.

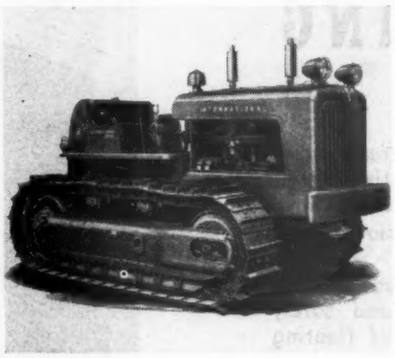
(12) *International tractor*

A new diesel crawler tractor in the 130 drawbar hp. range was announced by International Harvester during the Associated Equipment Distributors' meeting in Chicago the week of January 27. This latest addition to the International industrial power line, the TD-24, weighs approximately 35,000 lb. and is the largest tractor ever built by the company.

Features of the new tractor disclosed by the company include a new type of steering, giving the operator easy and positive control of the tractor; use of special sealing and anti-friction bearings in track rollers, greatly extending the track roller lubrication period; and convenient mounting for all types of allied equipment. The TD-24 is functionally streamlined, giving the operator a clear view of mounted equipment and the work in all directions. Additional contributions to driver comfort are the wide seat and convenient controls.

The TD-24 is designed with a horsepower-to-weight balance that ensures a high percentage of engine horsepower delivered at the drawbar. Eight speeds, from 1.6 to 7.8 m.p.h., give the big tractor great flexibility on all jobs. This wide speed range, plus fast, easy gear changing will greatly speed up round trip time cycles.

A new International 6-cylinder, full-diesel engine powers the TD 24. This engine will have the International built-in gasoline starting system that, together with an electric starter, assures easy starting in all weather conditions. The TD-24 engine also has many excellent features that are standard on current International diesels, such as replaceable



hardened cylinder sleeves, full pressure lubrication, Tocco hardened crankshaft, large diameter precision main and connecting rod bearings.

Production of the TD-24 will be a function of International's new Melrose Park Works, which has more than 2,000,000 sq. ft. of floor space. Since the plant will not be ready for use until the latter part of the year, it will be some time before the TD-24 will be available for sale.

(13) *Wire line valve*

Designed for use in any operation where tools or instruments are run in wells on wire line under pressure, the Omsco pressure seal wire line valve, manufactured by Oilfield Machine and Supply Company, Houston, Texas, permits the operator to shut in the well without severing the wire line.

The Omsco pressure seal wire line valve is applicable for use in running all wire line units for bottom hole pressure bombs, chokes, safety valves, paraffin scrapers of bottom hole samplers, and in fishing for those tools.

Tested to 6000 lb., the Omsco wire line valve has a full 2½ in. opening through the valve. It weighs approximately 100 lb. with overall dimensions of 14 in. by 7 in. by 10 in.

The Omsco pressure seal wire line valve is installed below the lubricator. It is designed with a built-in equalizing valve that provides simple, convenient operation. The built-in equalizing valve eliminates cumbersome outside lines. Rubber used in the rams is of the highest grade oil resistant type.

The pressure seal feature of the Omsco wire line valve is unusual in that it requires no adjustment. As more pressure is applied against the rams when the valve is closed, the rams seat even tighter. Rams are opened or closed by a 90 deg. turn of the ram arm.

The quick opening feature saves considerable time on jobs where multiple runs of tools or instruments are made. Rather than close the master gate of the christmas tree between runs, the well may be closed in by a quick turn of the ram arm.

The Omsco valve also includes other features of value.

CHROME CLAD
THE BEST TAPES
FOR THE
OIL INDUSTRY

The Lufkin "Anchor" Chrome Clad Steel Tape is just what you need for general measuring work. It's durable—the chrome "life jacket" protects the sturdy line against cracking, chipping, and peeling. It's easy to read—jet black markings are recessed so they can't wear out. It's easy to handle — convenient size, smooth working. And it's accurate — made to superior Lufkin standards. Order the Lufkin "Anchor" through your supply house. For free catalog write THE LUFKIN RULE CO., SAGINAW, MICH., New York City.

LUFKIN FOR ACCURACY

for exactly the Stainless Steel Tubing You Need for Any Tough Job

IN THE WIDE RANGE of Croloy Seamless and Welded Stainless Steel Tubes made by B&W are analyses that assure a close match between tubing properties and practically any tubing application requiring high resistance to corrosion, oxidation, scaling, breakage and creep at elevated or sub-zero temperatures. Many of these Stainless Steel analyses are available from no other source.

But the extent to which B&W can meet specific tube requirements *exactly* with Stainless Croloys goes beyond the usual commercial range of analyses. Developing special modified stainless analyses for unusual requirements in its extensive laboratory and producing them in its own modern *melting facilities* is a regular feature of B&W service on tube problems.

You can "call on Croloy", therefore, for Stainless Steel Tubing to match not just a wide range of severe service conditions, but *any* set of adverse operating conditions which only stainless steel tubing will satisfactorily withstand.

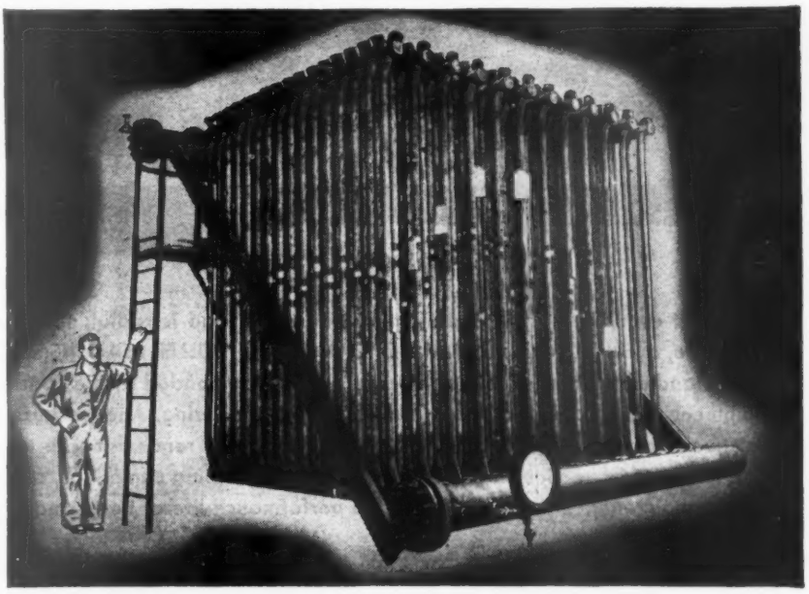
Ever since B&W produced the first stainless steel tubing commercially in the United States, Stainless Croloys have been helping to save time and expense in licking tough tubing problems in oil cracking, hydrogenation, reforming, polymerization, alkylation, gas cracking and other operations in refineries and synthetic rubber plants.

So for Stainless Tubes matched to tough jobs —exactly—call on Croloy.

CALL ON CROLOY

Stainless Tubing for *Effective Protection Against . . .*

WET CORROSION
DRY CORROSION
IMPAIRED FLOW
BREAKDOWN AT HIGH TEMPERATURES
SCALING
ALKALINE REACTIONS
GAS REACTIONS
EXCESSIVE RE-TUBING



Tubes in this huge catalyst case are made of a special B&W Stainless Steel developed to withstand unusually severe conditions.

Other B&W Products

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Water-Tube Boilers, for Stationary Power Plants, for Marine Service • Water-Cooled Furnaces • Superheaters • Economizers • Air Heaters • Pulverized-Coal Equipment • Chain-Grate Stokers • Oil, Gas and Multi-fuel Burners • Refractories • Process Equipment

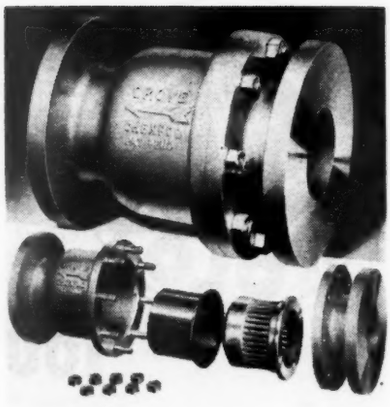
BABCOCK & WILCOX
SEAMLESS & WELDED TUBES
THE BABCOCK & WILCOX TUBE COMPANY
WELDED TUBE DIVISION • ALLIANCE, OHIO
SEAMLESS TUBE DIVISION • BEAVER FALLS, PA.

In event the packing in the stuffingbox on top of the lubricator fails, for example, the valve may be closed around the wire line. The well is thus shut in, allowing the operator to repack the stuffingbox.

In fishing operations the valve, in many instances, will save losing the fish, for the operator may shut the well in without severing the wire line. When the fish is caught and pulled to the top of the hole, the fishing tool will be in the lubricator while the caught fish is still below the master gate. With Omsco valve the fish may be removed by closing the valve, breaking off the stuffingbox to remove the fishing tool, then replace the stuffingbox and come out of the hole with the fish.

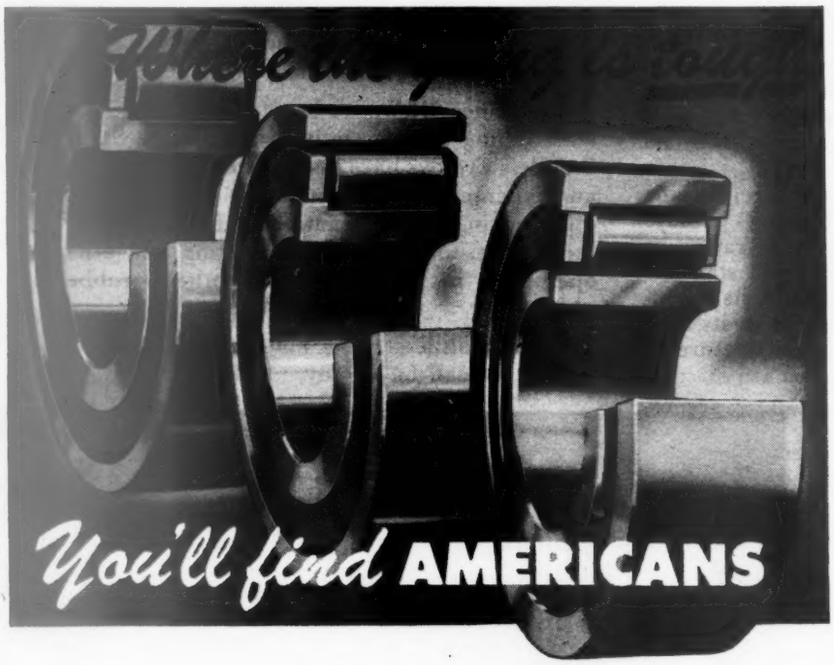
(14) *Check valve*

From the standpoint of design, construction and operation, the Grove Chexflo valve represents the utmost in simplicity and safety, according to the manufacturer, Grove Regulator Company, 6569 Green Street at 65th, Oakland 8, Califronia. Operation is effected by a synthetic rubber tube, stretched over a slotted, cup-shaped metal core, which expands to open and contracts to close. Due to the fact that this expansible tube closes instantly on balanced flow, prior to the beginning of back flow, there is never any tendency to establish pressure impulses, shock or water hammer through the flow line, it is asserted. The flexive tube, possesses a uniform and constant spring rate that avoids inertia being set up to cause operation beyond flow requirements. It likewise improves in service due to the fact that "flexing" adds life to rubber. Because of its self-compensating and wear resistant factors this unit is particularly suited for handling even the most highly corrosive and erosive air, gases, or liquids, it is stated.



(15) *No-burr bullet*

Schlumberger Well Surveying Corporation, Houston, Texas, has announced a gun-perforating bullet that, it is stated, leaves no burr on the inner wall of the casing. The "No-Burr" bullet consists of a standard Schlumberger bullet fitted with a metal disk, as illustrated. When the assembly is fired the flat face of the disk contacts the wall of the casing to prevent the formation of a burr.



For almost every *heavy duty* application where the load is radial, there is an adaptable, durable, dependable AMERICAN RADIAL ROLLER BEARING capable of withstanding the tremendous stresses and strains demanded by the ponderous equipment and stepped-up tempo of today's manufacturing. And because they are *specially* designed for "tough going," AMERICANS render smooth, continuous, trouble-free service under the most adverse operating conditions, resulting in lower maintenance costs and increased performance-life of heavy machinery and equipment.

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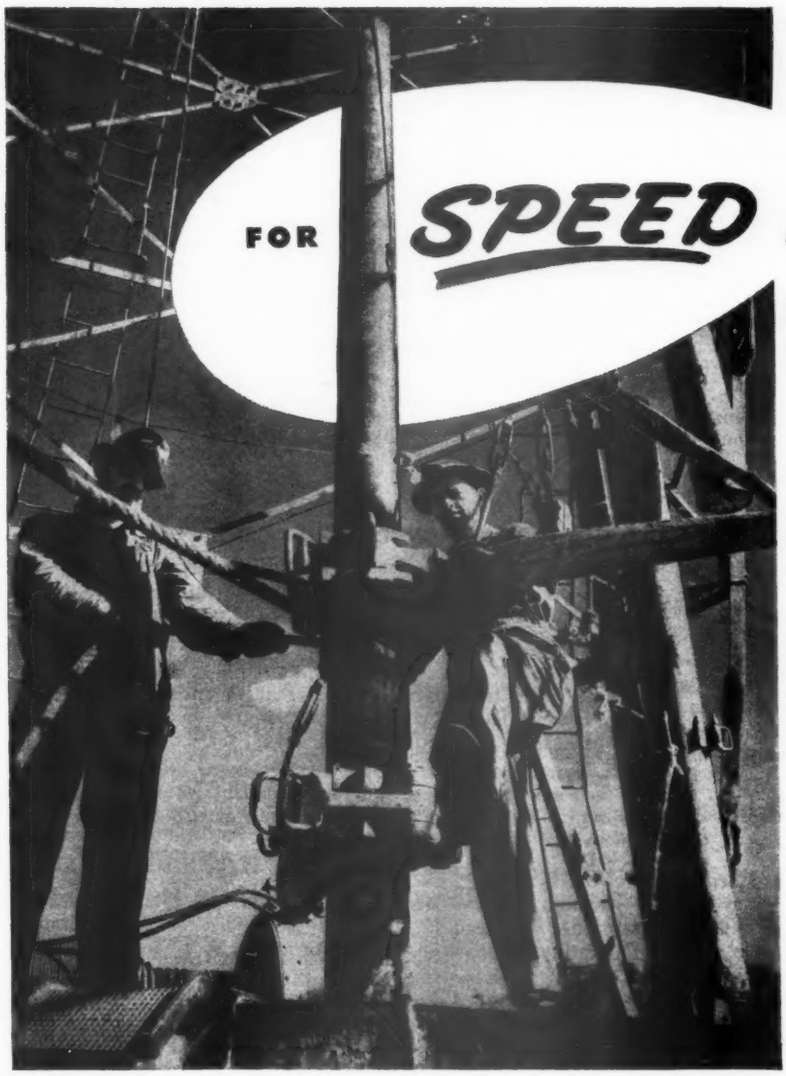

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With wells going deeper and deeper, you need all of the speed and safety you can obtain. The performance records of more than 100,000,000 feet of Republic Electric Weld Casing, produced in the past sixteen years, provide strong proof that this *modern* casing is unsurpassed on either of these counts.

There are other reasons, too, why cost-wise oil country men prefer to work with field-proved Republic Electric Weld Casing. For complete information, write to:

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TRADE LITERATURE

Publications listed are sent free upon request.

(16) *Condensers and coolers*

An important advancement in heat exchangers is explained in a new bulletin prepared by The Griscom Russell Company. The first part of the bulletin describes the Fin-Fan Exchanger, a "package-type" unit, jointly developed by The Griscom-Russell Company and The Fluor Corporation, Ltd. The final part of the bulletin describes the Griscom Russell K-Fin Air-Cooled Section in detail, and explains the design and construction that provide a compact, durable, and effective heat exchanger.

(17) *Valve designs*

Safety and relief valves to match the improved designs of the latest power and process equipment are announced in a catalog, No. 45, issued by the Farris Engineering Company. New valve designs, and improvements of old designs, now make a complete line of up-to-date safety and relief valves available from this company. An easy to use pictorial index shows line drawings of all the basic Farris valve types. With this index a valve user can pick out the valve he needs without having to thumb through a whole catalog. Directly opposite the pictorial index is a detailed index showing what the valve can be used for and where to find its specifications in the catalog.

(18) *Diesel engines*

Detroit Diesel Engine Division of General Motors Corporation has released an 8-page folder (Bulletin OFS 1), descriptive of the 3 General Motors Series 71 diesel engines for oil field use. The bulletin carries in each upper corner of the inside pages salient features of the Series 71 engine. Basic features and basic technical data on each engine are included, as well as power curves and installation dimensions. Flexibility of the Twin 6 and Quad 6 multiple engine units (in that one or more of the engines may be "cut out" by means of separate cluches) is described. On the back page, cutaway drawings show the transmission of power in these units to the power take-off shaft.

(19) *Restoring tower efficiency*

One of the most difficult oil refinery maintenance problems—the cleaning and descaling of bubble or absorber towers—is discussed in a 3-page illustrated article appearing in the November-December issue of *Oakite News Service*, house magazine of Oakite Products, Inc. Contrasting the costly, time-consuming dismantling or manual cleaning methods heretofore employed to modern, thorough chemical means of cleaning and descaling bubble or absorber towers, this interesting article describes methods and materials that are being widely used today to quickly and safely remove the heavy deposits of base sediment, sludge, gummy carbon, rust and scale that form in these towers and decrease their output, lessen their absorbing efficiency.

(20) *Care and handling of wire rope*

A series of 9 educational bulletins have been compiled by the Union Wire Rope Corporation, Kansas City, Missouri, to provide a reference index for the many industrial users of wire rope. The first installment has been published and is now available. Those requesting Bulletin No. 1 will automatically receive the additional issues at frequent intervals at no cost.

The educational series is comprehensive in illustrating the most efficient care and handling of wire rope to not only increase the service life of the rope but of the machinery with which it is used. To the industries using wire rope in any appreciable quantities, the information submitted should afford considerable savings in replacements and repairs.

(21) *Foxboro instrument line*

The Foxboro Company, Foxboro, Massachusetts, has issued Catalog 370, presenting the company's full line of recording and indicating instruments for measurement and control. Arranged for quick reference, and profusely illustrated, the sections deal with instruments for temperature applications, pressure, humidity, flow, liquid level, density, and other process variables. Control valves, planimeters, instrument accessories and supplies are included. This catalog is the first in which Foxboro has been able to show its line of Dynalog electronic instruments, the sale and use of which has, until recently, been limited to military applications.

(22) *Removable pump liner*

Blackmer Pump Company, Grand Rapids, Michigan, has issued Bulletin No. 307. This bulletin gives for the first time a comprehensive illustration and description of the new type of removable liner that is now standard construction in Blackmer power pumps.

(23) *Taylor level-buoy*

A complete description of the purpose, construction, and operation of the Taylor Level-Buoy Indicating Controller is contained in a new bulletin issued by the manufacturer, Taylor Instrument Companies. Outstanding features of the instrument are:

1. Pointer indication of level that is entirely mechanical and independent of controller air supply. Level-Buoy is also supplied as an indicating instrument only.
2. Frictionless and leakless Taylor torque tube transmission of float movement to instrument mechanism. No packing glands, ground joint seals, internal pivots, or wearing surfaces are involved.
3. Taylor Fulscope control in any of the 5 standard forms.

Standard ranges are 14, 32, 60 and 120 inches of water. Optional ranges of 48, 72, 84, 96 and 108 inches are available. Operating temperature limits are minus 30°F. to plus 500°F.

(24) *Welded fabrication*

A new engineering manual entitled, "Tailoring in Metal," is offered by The United Welding Company, Middletown, Ohio. It discusses the factors effecting the choice of welded fabrication and the techniques of welded design. As stated by the author, the purpose of the manual is to help engineers and designers decide for themselves whether fabrication by welding and the materials made available by this method are applicable to the problem. The factors involved in a decision are cost, weight, strength, appearance, stability, noise, quality, and delivery.

(25) *How to cut cast iron*

The Technical Service Department of National Cylinder Gas Company, Chicago, Illinois, has issued an illustrated circular covering the "how to" on the cutting of cast iron with the oxy-acetylene flame. For many years cast iron cutting was considered almost impossible, but now with proper apparatus and technique the job can be done both successfully and economically. Included is discussion of proper types of equipment, preheating conditions, cutting positions, need of adequate protective clothing, proper oxygen and acetylene pressures, etc.

(26) *Bristol general catalog*

A new postwar general catalog entitled, "Specification Index for Bristol Instruments," has been published by The Bristol Company, Waterbury, Connecticut. The catalog, No. W1800, contains 24 pages of information on the Bristol line of automatic controlling, recording, and indicating instruments and gives hints on how they can be used effectively to save time and money and promote efficient operation. Specification data is given on each instrument listed. The booklet is liberally illustrated with line drawings, which show basic methods of applying various types of industrial instruments.

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT NO. 104

A VALUABLE and regular feature of *The Petroleum Engineer*, the Continuous Tables, now in their eighth year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer*. Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944, issue; 83-85, inclusive, in the July, 1944, issue; 86-88, inclusive, in the October, 1944, issue; 89-91, inclusive, in the January, 1945, issue; 92-94, inclusive, in the April, 1945, issue; 95-97, inclusive, in the July, 1945, issue; 98-100, inclusive, in the October, 1945, issue, and 101-103, inclusive, in the January, 1946, issue.

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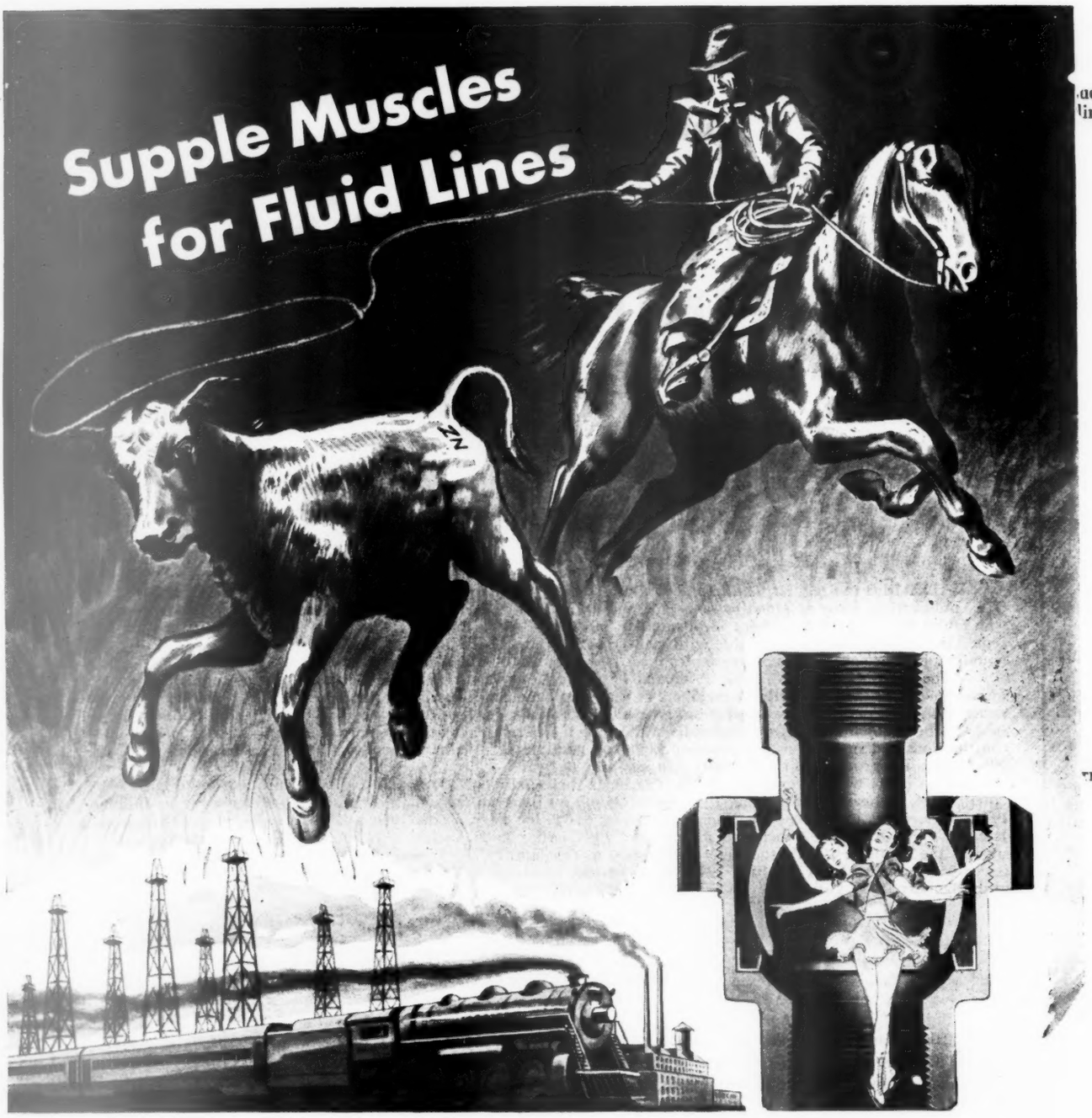
Supple Muscles for Fluid Lines



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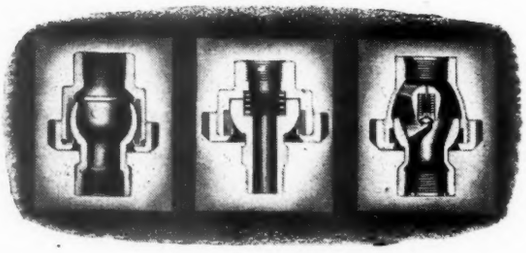

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In Canada: The Holden Co., Ltd., Montreal, Canada

"MOVE IN EVERY DIRECTION"

VOLUME CORRECTION FACTORS FOR C_4 HYDROCARBON MIXTURES

TABLE 5

Vapor Volume Correction Factors for C_4 Hydrocarbon Mixture

Vapor pressure, lb. per sq. in., abs.	Liquid specific gravity at 60°/60° F.							
	0.56	0.57	0.58	0.59	0.60	0.61	0.62	0.63
	(Volume of liquid at 60 °F. occupied by unit volume of vapor at pressure indicated)							
120	0.0371	0.0360	0.0350	0.0342	0.0333	0.0323	0.0312	0.0301
118	0.0365	0.0354	0.0344	0.0336	0.0328	0.0318	0.0307	0.0296
116	0.0359	0.0348	0.0338	0.0330	0.0322	0.0313	0.0302	0.0291
114	0.0353	0.0342	0.0333	0.0325	0.0317	0.0308	0.0297	0.0286
112	0.0347	0.0336	0.0327	0.0309	0.0311	0.0302	0.0292	0.0281
110	0.0341	0.0330	0.0321	0.0314	0.0306	0.0297	0.0287	0.0276
108	0.0334	0.0324	0.0315	0.0308	0.0300	0.0291	0.0282	0.0271
106	0.0328	0.0318	0.0309	0.0302	0.0295	0.0286	0.0277	0.0266
104	0.0322	0.0312	0.0304	0.0297	0.0289	0.0281	0.0272	0.0261
102	0.0316	0.0306	0.0298	0.0291	0.0284	0.0275	0.0267	0.0256
100	0.0310	0.0300	0.0292	0.0285	0.0278	0.0270	0.0261	0.0251
98	0.0304	0.0294	0.0287	0.0279	0.0272	0.0264	0.0256	0.0246
96	0.0298	0.0288	0.0281	0.0274	0.0267	0.0259	0.0251	0.0241
94	0.0292	0.0282	0.0275	0.0268	0.0261	0.0254	0.0245	0.0236
92	0.0286	0.0276	0.0269	0.0262	0.0256	0.0248	0.0240	0.0231
90	0.0280	0.0271	0.0263	0.0256	0.0250	0.0243	0.0235	0.0226
88	0.0274	0.0265	0.0257	0.0251	0.0245	0.0237	0.0230	0.0222
86	0.0268	0.0259	0.0251	0.0245	0.0239	0.0232	0.0224	0.0217
84	0.0262	0.0253	0.0246	0.0240	0.0233	0.0227	0.0220	0.0212
82	0.0256	0.0247	0.0240	0.0234	0.0228	0.0221	0.0215	0.0207
80	0.0250	0.0241	0.0234	0.0228	0.0222	0.0216	0.0209	0.0202
78	0.0243	0.0235	0.0228	0.0222	0.0217	0.0211	0.0204	0.0197
76	0.0237	0.0229	0.0222	0.0217	0.0211	0.0205	0.0199	0.0192
74	0.0231	0.0223	0.0217	0.0211	0.0206	0.0200	0.0194	0.0187
72	0.0225	0.0217	0.0211	0.0206	0.0200	0.0194	0.0189	0.0182
70	0.0219	0.0212	0.0205	0.0200	0.0195	0.0189	0.0183	0.0177
68	0.0213	0.0206	0.0199	0.0194	0.0189	0.0184	0.0178	0.0172
66	0.0207	0.0200	0.0194	0.0189	0.0184	0.0179	0.0173	0.0167
64	0.0201	0.0194	0.0188	0.0183	0.0178	0.0173	0.0168	0.0162
62	0.0195	0.0188	0.0182	0.0177	0.0173	0.0168	0.0163	0.0157

—From National Bureau of Standards Letter Circular LC757.

PRACTICAL PROBLEMS

Problem 3. Calculate the contents of a sphere, expressed as gal. of liquid at 60°F. from the following:

Data: (1) The total volume of sphere is 10,000 bbl.

(2) Liquid level measurements indicate 8,000 bbl. of liquid.

(3) Specific gravity of liquid determined as 0.6100 at 60°/60°F.

(4) Instruments on the sphere indicate a pressure of 49 lb. per sq. in. gage, and a liquid temperature of 84°F.

Calculations: (a) From Table 2 (Sheet 2 published in installment No. 102) and a vapor pressure at 84°F. of 63.7 lb. per sq. in., absolute, the estimated vapor pressure at 100°F. is 80 lb. per sq. in., absolute.

(b) From table 4 (sheet 4 published in installment No. 103), the liquid volume correction factor for 84°F. and a vapor pressure at 100°F. of 80 lb. per sq. in., absolute, is 0.9702.

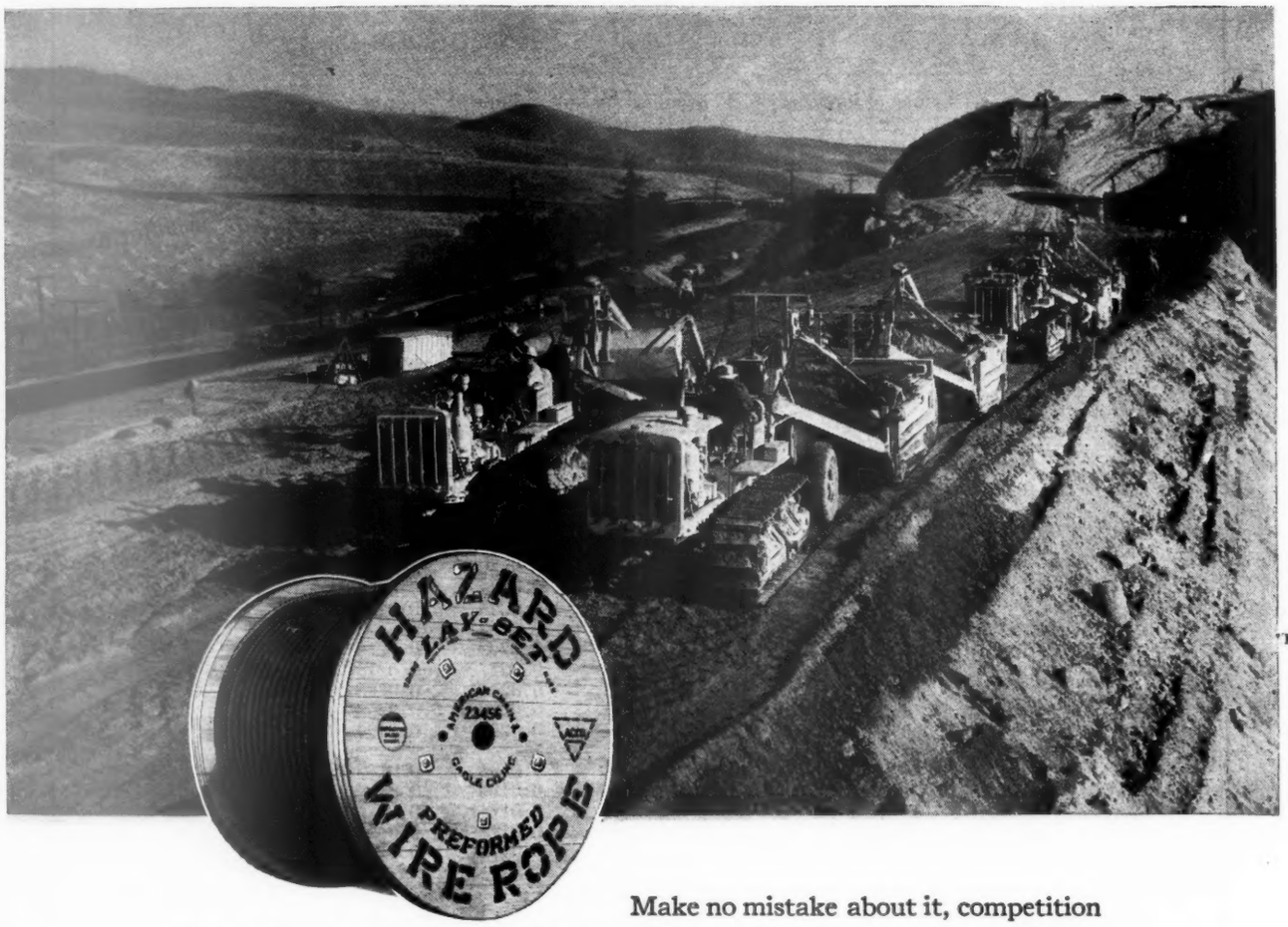
(c) 8000 bbl. or 336,000 gal. of liquid at 84°F. = (336,000) (0.9702) = 325,987 gal. of liquid at 60°F.

(d) From table 5 (above) the vapor volume correction factor for 64 lb. per sq. in., absolute, and liquid specific gravity of 0.61 at 60°/60°F. is 0.0173.

(e) 200 bbl. or 84,000 gal. of vapor at 49 lb. per sq. in., gage = (84,000) (0.0173) = 1453 gal. of liquid at 60°F.

(f) The total contents of the sphere, corrected to liquid at 60°F. = 325,987 + 1,453 = 327,440 gal. of liquid at 60°F.

Get your equipment ready for the huge A.R.B.A. road-building program



Make no mistake about it, competition during 1946 is going to be tough. With costs higher all along the line, profits will depend upon operating efficiency. With the A.R.B.A. road and airport building program starting this spring, see to it *now* that your equipment is in tip-top condition. And for long wear with steady production equip your machines with Hazard LAY-SET Preformed Wire Rope. There is no better, safer, more uniform wire rope than Hazard LAY-SET Preformed made of Improved Plow Steel.

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In Business for Your Safety

VOLUME CORRECTION FACTORS FOR C_4 HYDROCARBON MIXTURES

TABLE 5—*Continued*

Vapor Volume Correction Factors for C_4 Hydrocarbon Mixture

Vapor pressure, lb. per sq. in., abs.	Liquid specific gravity at 60°/60° F.							
	0.56	0.57	0.58	0.59	0.60	0.61	0.62	0.63
	(Volume of liquid at 60 °F. occupied by unit volume of vapor at pressure indicated)							
60	0.0189	0.0182	0.0176	0.0172	0.0168	0.0163	0.0158	0.0153
58	0.0183	0.0177	0.0171	0 0166	0.0162	0.0157	0.0152	0.0148
56	0.0178	0.0171	0.0165	0.0161	0.0156	0.0152	0.0137	0.0143
54	0.0172	0.0165	0.0159	0.0155	0.0151	0.0146	0.0142	0.0138
52	0.0166	0.0160	0.0154	0.0150	0.0145	0.0141	0.0137	0.0133
50	0.0160	0.0154	0.0149	0.0144	0.0140	0.0136	0.0132	0.0128
48	0.0154	0.0148	0.0143	0.0139	0.0135	0.0131	0.0127	0.0123
46	0.0148	0.0142	0.0137	0.0133	0.0129	0.0125	0.0122	0.0118
44	0.0142	0.0137	0.0132	0.0128	0.0124	0.0120	0.0117	0.0113
42	0.0136	0.0131	0.0126	0.0122	0.0118	0.0115	0.0112	0.0108
40	0.0130	0.0125	0.0121	0.0117	0.0113	0.0110	0.0107	0.0103
38	0.0124	0.0119	0.0115	0.0111	0.0108	0.0105	0.0102	0.0098
36	0.0118	0.0113	0.0109	0.0106	0.0102	0.0099	0.0097	0.0094
34	0.0111	0.0107	0.0103	0.0100	0.0097	0.0094	0.0092	0.0089
32	0.0105	0.0101	0.0098	0.0095	0.0092	0.0089	0.0086	0.0084
30	0.0099	0.0095	0.0092	0.0089	0.0086	0.0083	0.0081	0.0079
28	0.0093	0.0089	0.0086	0.0083	0.0080	0.0078	0.0076	0.0074
26	0.0087	0.0083	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069
24	0.0080	0.0077	0.0075	0.0072	0.0069	0.0067	0.0066	0.0064
22	0.0074	0.0071	0.0069	0.0067	0.0064	0.0062	0.0060	0.0059
20	0.0068	0.0065	0.0063	0.0061	0.0059	0.0057	0.0055	0.0054
18	0.0062	0.0059	0.0057	0.0055	0.0053	0.0051	0.0050	0.0049
16	0.0055	0.0053	0.0051	0.0049	0.0047	0.0046	0.0045	0.0044
14	0.0049	0.0047	0.0045	0.0044	0.0042	0.0040	0.0039	0.0039
12	0.0042	0.0040	0.0039	0.0038	0.0036	0.0035	0.0034	0.0033
10	0 0035	0.0034	0.0033	0.0032	0.0030	0.0029	0.0028	0.0028
8	0.0028	0.0027	0.0026	0.0026	0.0024	0.0024	0.0024	0.0023
6	0.0021	0.0020	0.0019	0.0019	0.0018	0.0018	0.0018	0.0017
4	0.0014	0.0013	0.0013	0.0012	0.0012	0.0012	0.0012	0.0012
2	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006

—From National Bureau of Standards Letter Circular LC757.

PRACTICAL PROBLEMS

Problem 4. Calculate the quantity of material transferred from a sphere from the following:

Data: The initial contents of the sphere were as cited in probem 3. After the transfer, measurements indicated 2000 bbl. of liquid at 79°F. and a pressure of 44 lb. per sq. in., gage.

Calculations: (a) From table 4 (sheet 4 published in installment No. 103), the liquid volume correction factor for 79°F. and a vapor pressure at 100°F. of 80 lb. per sq. in., absolute, is 0.9766.

(b) 2000 bbl. or 84,000 gal. of liquid at 79°F. = (84,000) (0.9766) = 82,034 gal. of liquid at 60°F.

(c) From table 5, the vapor volume correction factor for a vapor pressure of 59 lb. per sq. in., absolute, and a liquid specific gravity of 0.61 at 60°/60°F. is 0.0160 (by interpolation in above table).

(d) 8000 bbl. or 336,000 gal. of vapor at 59 lb. per sq. in., absolute = (336,000 (0.0160) = 5,376 gal. of liquid at 60°F.

(e) The final contents of the sphere = 82,034 + 5,376 = 87,410 gal. of liquid at 60°F.

(f) The quantity of material transferred = difference between initial and final contents = 327,440 — 87,410 = 240,030 gal. at 60°F.

BUILD THE *New* WITH *Better* PIPE TOOLS!

Save man-hours and muscle in your pipe threading operations—with TOLEDO Pipe Tools! These easy-threading tools are engineered to do a better job and help you *cut costs!* Unbeatable for accurate, dependable operation—preferred by experienced mechanics for nearly half a century.

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VAPOR PRESSURE BLENDING CURVES FOR COMMERCIAL BUTANE

NOTE: Fig. 12 is designed for use with a 500 bbl. tank with a safe filling capacity of 20,500 gal., and for addition of 300 lb. per sq. in. reflux. It can be used for a final blend of more or less than 20,500 gal. simply by multiplying the answer by a factor = $\frac{\text{final gal.}}{20{,}500 \text{ gal.}}$

EXAMPLE OF CHART USE:

Given: 19,500 gal. of 65 lb. butane mixture.

Required: 20,500 gal. of 95 lb. per sq. in. final blend.

Solution: Enter the graph on the 65 lb. line on the vertical scale. Proceed to the curve which begins at the 95 lb. line on the vertical scale as indicated. Then, proceed downward to the horizontal scale. The reading is 2320 gal. of 300 lb. reflux to be added. Therefore, the original 19,500 gal. of butane mixture should be drawn down to 20,500 — 2320, or 18,180 gal. before adding the 300 lb. reflux. Then, by drawing off 1320 gal. of the original 65 lb. mixture and adding 2320 gal. of 300 lb. reflux, the final volume will be 20,500 gal. of 95 lb. per sq. in. product.

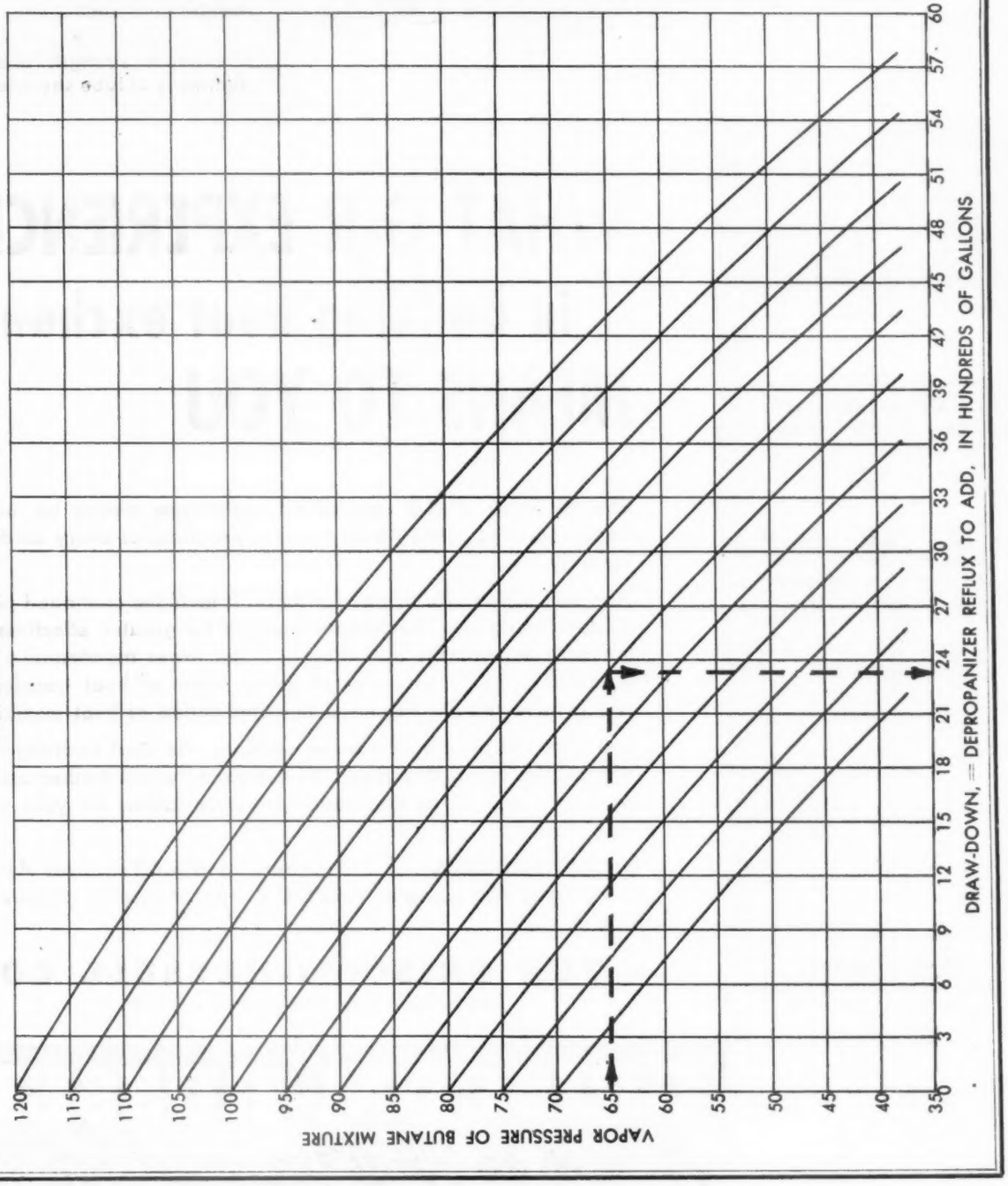
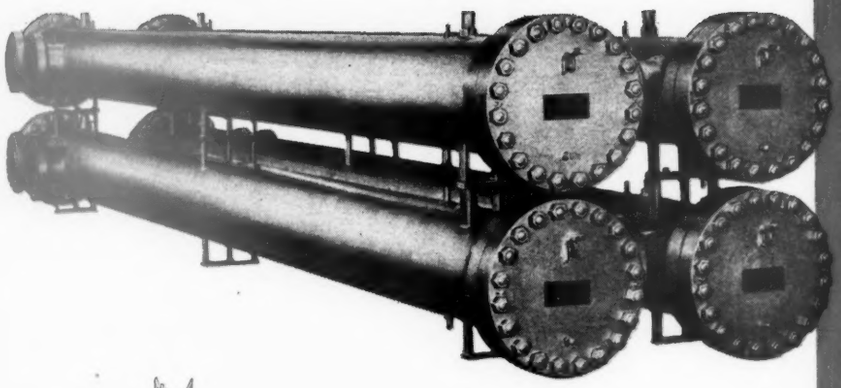


FIG. 12. Draw-down curve for a 20,500 gal. maximum safe capacity tank when vapor pressure of depropanizer reflux is 300 lb. per sq. in. at 100°F.



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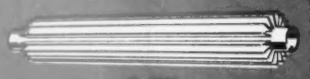

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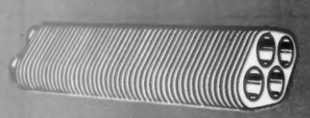
Longitudinal-finned elements for greater heat conductivity

K-FIN
Helical-finned elements for vapors and gases

DENTUBE SECTIONS
with scale-shedding elements for hard or salt water



TUBEFLO SECTIONS
Non-clogging design for residuum and other dirty fluids

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RECIPROCALS, CIRCUMFERENCES, AND AREAS OF CIRCLES

Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$	Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$
				50	20.000 00	157.079 6	1 963.495
1	1000.000	3.141 593	.785 3982	51	19.607 84	160.221 2	2 042.821
2	500.000 0	6.283 185	3.141 593	52	19.230 77	163.362 8	2 123.717
3	333.333 3	9.424 778	7.068 583	53	18.867 92	166.504 4	2 206.183
4	250.000 0	12.566 37	12.566 37	54	18.518 82	169.646 0	2 290.221
5	200.000 0	15.707 96	19.634 95	55	18.181 82	172.787 6	2 375.829
6	166.666 7	18.849 56	28.274 33	56	17.857 14	175.929 2	2 463.009
7	142.857 1	21.991 15	38.484 51	57	17.543 86	179.070 8	2 551.759
8	125.000 0	25.132 74	50.265 48	58	17.241 38	182.212 4	2 642.079
9	111.111 1	28.274 33	63.617 25	59	16.949 15	185.354 0	2 733.971
10	100.000 0	31.415 93	78.539 82	60	16.666 67	188.495 6	2 827.433
11	90.909 09	34.557 52	95.033 18	61	16.393 44	191.637 2	2 922.467
12	83.333 33	37.699 11	113.097 3	62	16.129 03	194.778 7	3 019.071
13	76.923 08	40.840 70	132.732 3	63	15.873 02	197.920 3	3 117.245
14	71.428 57	43.982 30	153.938 0	64	15.625 00	201.061 9	3 216.991
15	66.666 67	47.123 89	176.714 6	65	15.384 62	204.203 5	3 318.307
16	62.500 00	50.265 48	201.061 9	66	15.151 52	207.345 1	3 421.194
17	58.823 53	53.407 08	226.980 1	67	14.925 37	210.486 7	3 525.652
18	55.555 56	56.548 67	254.469 0	68	14.705 88	213.628 3	3 631.681
19	52.631 58	59.690 26	283.528 7	69	14.492 75	216.769 9	3 739.281
20	50.000 00	62.831 85	314.159 3	70	14.285 71	219.911 5	3 848.451
21	47.619 05	65.973 45	346.360 6	71	14.084 51	223.053 1	3 959.192
22	45.454 55	69.115 04	380.132 7	72	13.888 89	226.194 7	4 071.504
23	43.478 26	72.256 63	415.475 6	73	13.698 63	229.336 3	4 185.387
24	41.666 67	75.398 22	452.389 3	74	13.513 51	232.477 9	4 300.840
25	40.000 00	78.539 82	490.873 9	75	13.333 33	235.619 4	4 417.865
26	38.461 54	81.681 41	530.929 2	76	13.157 89	238.761 0	4 536.460
27	37.037 04	84.823 00	572.555 3	77	12.987 01	241.902 6	4 656.626
28	35.714 29	87.964 59	615.752 2	78	12.820 51	245.044 2	4 778.362
29	34.482 76	91.106 19	660.519 9	79	12.658 23	248.185 8	4 901.670
30	33.333 33	94.247 78	706.858 3	80	12.500 00	251.327 4	5 026.548
31	32.258 06	97.389 37	754.767 6	81	12.345 68	254.469 0	5 152.997
32	31.250 00	100.531 0	804.247 7	82	12.195 12	257.610 6	5 281.017
33	30.303 03	103.672 6	855.298 6	83	12.048 19	260.752 2	5 410.608
34	29.411 76	106.814 2	907.920 3	84	11.904 76	263.893 8	5 541.769
35	28.571 43	109.955 7	962.112 8	85	11.764 71	267.035 4	5 674.502
36	27.777 78	113.097 3	1 017.876	86	11.627 91	270.177 0	5 808.805
37	27.027 03	116.238 9	1 075.210	87	11.494 25	273.318 6	5 944.679
38	26.315 79	119.380 5	1 134.115	88	11.363 64	276.460 2	6 082.123
39	25.641 03	122.522 1	1 194.591	89	11.235 96	279.601 7	6 221.139
40	25.000 00	125.663 7	1 256.637	90	11.111 11	282.743 3	6 361.725
41	24.390 24	128.805 3	1 320.254	91	10.989 01	285.884 9	6 503.882
42	23.809 52	131.946 9	1 385.442	92	10.869 57	289.026 5	6 647.610
43	23.255 81	135.088 5	1 452.201	93	10.752 69	292.168 1	6 792.909
44	22.727 27	138.230 1	1 520.531	94	10.638 30	295.309 7	6 939.778
45	22.222 22	141.371 7	1 590.431	95	10.526 32	298.451 3	7 088.218
46	21.739 13	144.513 3	1 661.903	96	10.416 67	301.592 9	7 238.229
47	21.276 60	147.654 9	1 734.945	97	10.309 28	304.734 5	7 389.811
48	20.833 33	150.796 4	1 809.557	98	10.204 08	307.876 1	7 542.964
49	20.408 16	153.938 0	1 885.741	99	10.101 01	311.017 7	7 697.687

Note: n may be in any unit of measure, such as in., ft., yards, miles, meters, or fractions thereof.

Example: The diameter of a circle = 0.83 in.

Then, the circumference = $0.83 \times \pi = 2.607522$ in. (The figure shown opposite 83 pointed off for the fraction); and the area = .5410608 sq. in. *Notice* that the decimal point is moved *the same number of places* to the left in pointing off for the circumference, and twice the *number of places* to the left for the area.

The *reciprocal* of a number is simply the quotient of unity (1000 is taken as unity in this table) divided by the number. It is useful in determining decimal equivalents of fractions.

Example: Opposite 64 (above), the reciprocal $\left(\frac{1000}{64}\right) = 15.62500$. Then, the decimal equivalent of the fraction 1/64 in. = 0.015625 in. *Notice* that the decimal point is moved *the same number* of places in the numerator of the fraction as in the answer, but in opposite directions.

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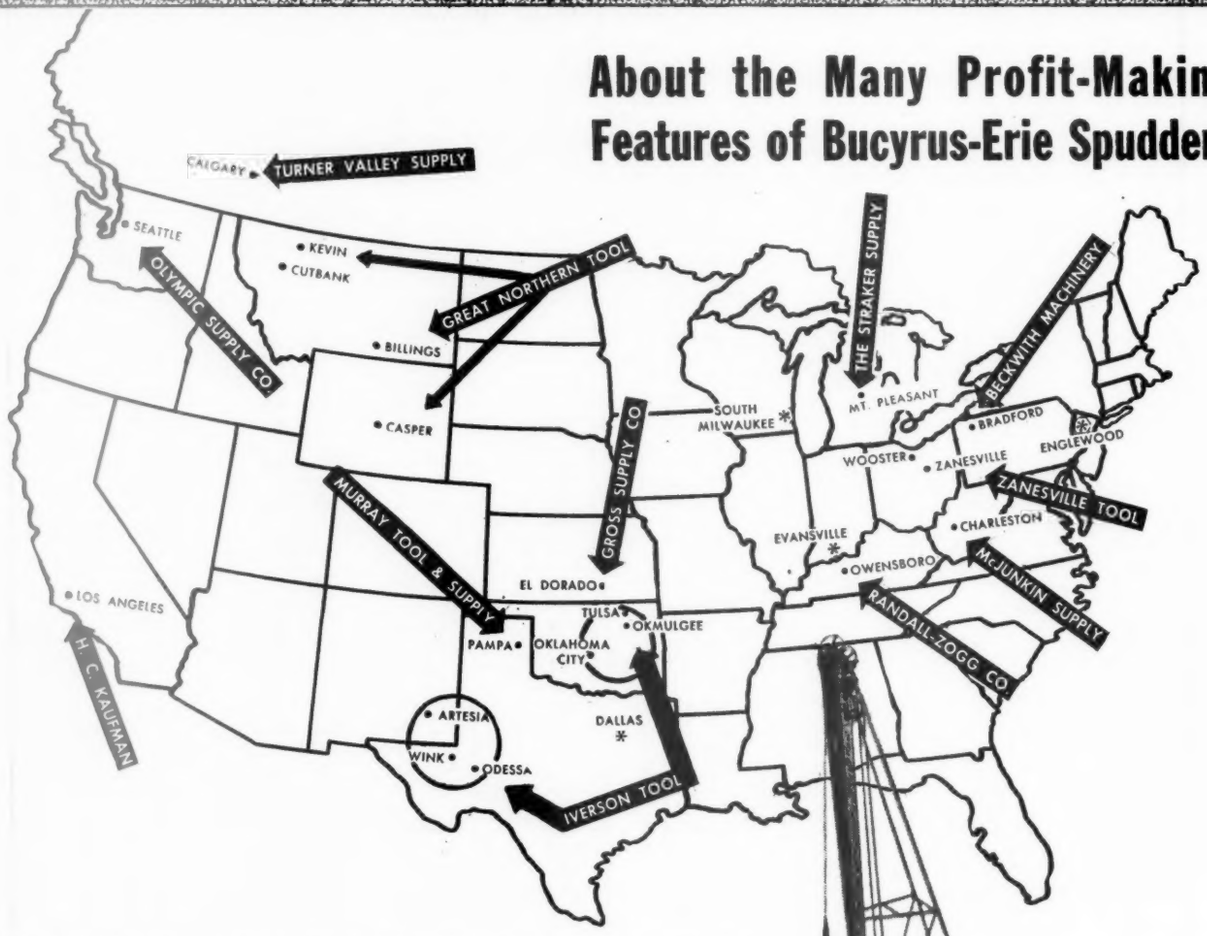

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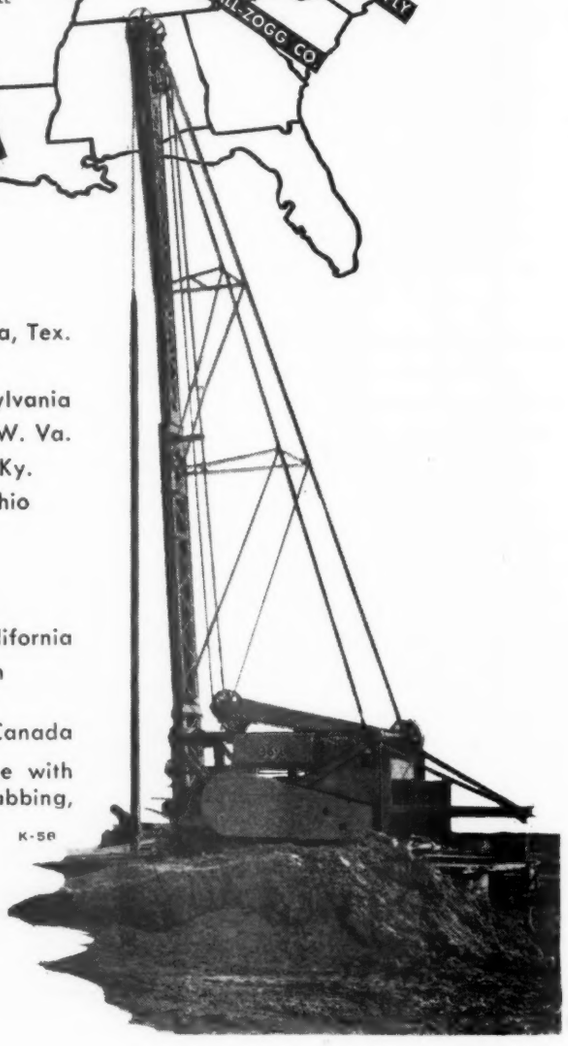

BUCYRUS ERIE

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VOLUME CORRECTION FACTORS FOR PETROLEUM OILS

Observed temp., °F.	6 deg. API 1.0291 sp. gr. Group 0 or H	22 deg. API 0.9218 sp. gr. Group 1 or G	44 deg. API 0.8063 sp. gr. Group 2 or F	58 deg. API 0.7467 sp. gr. Group 3 or E†	72 deg. API 0.6953 sp. gr. Group 4 or D	86 deg. API 0.6506 sp. gr. Group 5 or C	91 deg. API 0.6360 sp. gr. Group 6 or B
120	0.9792	0.9763	0.9702	0.9635	0.9574	0.9513	0.9487
121	0.9789	0.9759	0.9697	0.9629	0.9567	0.9505	0.9479
122	0.9785	0.9755	0.9692	0.9623	0.9560	0.9497	0.9470
123	0.9782	0.9752	0.9687	0.9617	0.9552	0.9489	0.9462
124	0.9779	0.9748	0.9682	0.9611	0.9545	0.9480	0.9453
125	0.9775	0.9744	0.9677	0.9605	0.9538	0.9472	0.9444
126	0.9772	0.9740	0.9672				
127	0.9768	0.9736	0.9667				
128	0.9765	0.9732	0.9662				
129	0.9762	0.9728	0.9657				
130	0.9758	0.9724	0.9652				
131	0.9755	0.9720	0.9647				
132	0.9751	0.9716	0.9642				
133	0.9748	0.9713	0.9637				
134	0.9745	0.9709	0.9632				
135	0.9741	0.9705	0.9627				
136	0.9738	0.9701	0.9622				
137	0.9735	0.9697	0.9617				
138	0.9731	0.9694	0.9613				
139	0.9728	0.9690	0.9608				
140	0.9724	0.9686	0.9603				
141	0.9721	0.9682	0.9598				
142	0.9718	0.9678	0.9593				
143	0.9714	0.9675	0.9588				
144	0.9711	0.9671	0.9583				
145	0.9707	0.9667	0.9578				
146	0.9704	0.9663	0.9573				
147	0.9701	0.9659	0.9568				
148	0.9697	0.9655	0.9563				
149	0.9694	0.9651	0.9558				
150	0.9691	0.9647	0.9553				
151	0.9687	0.9643					
152	0.9684	0.9639					
153	0.9680	0.9636					
154	0.9677	0.9632					
155	0.9674	0.9628					
156	0.9670	0.9624					
157	0.9667	0.9620					
158	0.9664	0.9616					
159	0.9660	0.9612					
160	0.9657	0.9608					
161	0.9654	0.9604					
162	0.9650	0.9601					
163	0.9647	0.9597					
164	0.9463	0.9594					
165	0.9640	0.9590					
166	0.9637	0.9586					
167	0.9633	0.9582					
168	0.9630	0.9578					
169	0.9627	0.9474					
170	0.9623	0.9570					
171	0.9620	0.9566					
172	0.9616	0.9562					
173	0.9613	0.9559					
174	0.9610	0.9555					
175	0.9606	0.9551					
176	0.9603	0.9547					
177	0.9600	0.9543					
178	0.9596	0.9540					
179	0.9593	0.9536					

Explanation: These tables show the volume occupied at 60°F. by a quantity of oil occupying unit volume at the observed temperature. Values in the tables are in the form of multipliers; that is, the volume of oil at the indicated or observed temperature and degrees API or specific gravity for each group, multiplied by the corresponding factor in the table, equals the volume at 60°F.

Example: If the gravity of an oil is 25 deg. API at 60°F., it is in Group I or G, and the volume at 130°F. equals 10,000 bbl., then the volume at 60°F. would equal 10,000 × 0.9724 or 9724 bbl.

Observed temp., °F.	6 deg. API 1.0291 sp.gr. Group 0 or H	22 deg. API 0.9218 sp.gr. Group 1 or G	Observed temp., °F.	6 deg. API 1.0291 sp.gr. Group 0 or H	22 deg. API 0.9218 sp.gr. Group 1 or G
180	0.9590	0.9532	205	0.9507	0.9438
181	0.9586	0.9528	206	0.9504	0.9434
182	0.9583	0.9524	207	0.9500	0.9430
183	0.9580	0.9521	208	0.9497	0.9427
184	0.9576	0.9517	209	0.9494	0.9423
185	0.9573	0.9513	210	0.9490	0.9419
186	0.9569	0.9509	211	0.9487	0.9415
187	0.9566	0.9505	212	0.9484	0.9412
188	0.9563	0.9502	213	0.9481	0.9408
189	0.9559	0.9498	214	0.9477	0.9405
190	0.9556	0.9494	215	0.9474	0.9401
191	0.9553	0.9490	216	0.9471	0.9397
192	0.9549	0.9487	217	0.9468	0.9393
193	0.9546	0.9483	218	0.9464	0.9390
194	0.9543	0.9480	219	0.9461	0.9386
195	0.9539	0.9476	220	0.9458	0.9382
196	0.9536	0.9472	221	0.9454	0.9378
197	0.9533	0.9468	222	0.9451	0.9374
198	0.9530	0.9465	223	0.9448	0.9371
199	0.9527	0.9461	224	0.9445	0.9367
200	0.9523	0.9457	225	0.9441	0.9363
201	0.9520	0.9453	226	0.9438	0.9359
202	0.9517	0.9449	227	0.9435	0.9356
203	0.9513	0.9446	228	0.9432	0.9352
204	0.9510	0.9442	229	0.9428	0.9349

†All motor fuel blends of gasoline and benzol shall be considered as falling in Group 3 or E.

For additional information about the groups, see Sheet 5, P 213.2, and for the first two sheets of this series of tables, see the January, 1946, issue of The Petroleum Engineer.

This Simple Compressor Meets the Complex Needs of a Changing Petroleum Industry

It's the Nash!

Here is a compressor presenting advantages found in no other device. Nash Compressors have only one moving part, rotating without metallic contact with the pump casing. No internal lubrication is required. Yet they produce 75 lbs. pressure in a single stage, with capacities to 6 million cu. ft. per day in a single structure.

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One moving part.

No internal wearing parts.

No valves, pistons, or sliding vanes.

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Low maintenance.

Slugs of liquid entering pump do no harm.

Non-pulsating pressure.

Saves floor space.

75 pounds in a single stage.

NASH ENGINEERING COMPANY

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VOLUME CORRECTION FACTORS FOR PETROLEUM OILS

Observed temp., °F.	6 deg. API 1.0291 sp.gr. Group 0 or H	22 deg. API 0.9218 sp.gr. Group 1 or G	Observed temp., °F.	6 deg. API 1.0291 sp.gr. Group 0 or H	22 deg. API 0.9218 sp.gr. Group 1 or G	Observed temp., °F.	6 deg. API 1.0291 sp.gr. Group 0 or H	22 deg. API 0.9218 sp.gr. Group 1 or G
230	0.9425	0.9345	290	0.9233	0.9124	350	0.9045	0.8909
231	0.9422	0.9341	291	0.9229	0.9120	351	0.9042	0.8906
232	0.9419	0.9337	292	0.9226	0.9117	352	0.9039	0.8902
233	0.9415	0.9334	293	0.9223	0.9113	353	0.9036	0.8899
234	0.9412	0.9330	294	0.9220	0.9110	354	0.9033	0.8895
235	0.9409	0.9326	295	0.9217	0.9106	355	0.9030	0.8892
236	0.9406	0.9322	296	0.9214	0.9102	356	0.9027	0.8888
237	0.9402	0.9318	297	0.9210	0.9099	357	0.9024	0.8884
238	0.9399	0.9315	298	0.9207	0.9095	358	0.9021	0.8881
239	0.9396	0.9311	299	0.9204	0.9091	359	0.9017	0.8877
240	0.9392	0.9307	300	0.9201	0.9088	360	0.9014	0.8874
241	0.9389	0.9303	301	0.9198	0.9084	361	0.9011	0.8870
242	0.9386	0.9300	302	0.9195	0.9081	362	0.9008	0.8867
243	0.9383	0.9296	303	0.9191	0.9077	363	0.9005	0.8863
244	0.9380	0.9293	304	0.9188	0.9073	364	0.9002	0.8860
245	0.9676	0.9289	305	0.9185	0.9070	365	0.8999	0.8856
246	0.9373	0.9285	306	0.9182	0.9066	366	0.8996	0.8853
347	0.9370	0.9281	307	0.9179	0.9063	367	0.8993	0.8849
248	0.9367	0.9278	308	0.9176	0.9059	368	0.8990	0.8846
249	0.9364	0.9274	309	0.9173	0.9055	369	0.8987	0.8842
250	0.9360	0.9270	310	0.9169	0.9052	370	0.8974	0.8839
251	0.9357	0.9267	311	0.9166	0.9048	371	0.8981	0.8835
252	0.9354	0.9263	312	0.9163	0.9045	372	0.8978	0.8832
253	0.9351	0.9259	313	0.9160	0.9041	373	0.8975	0.8828
254	0.9347	0.9256	314	0.9157	0.9037	374	0.8972	0.8825
255	0.9344	0.9252	315	0.9154	0.9034	375	0.8969	0.8821
256	0.9341	0.9248	316	0.9151	0.9030	376	0.8965	0.8818
257	0.9338	0.9245	317	0.9148	0.9027	377	0.8962	0.8814
258	0.9335	0.9241	318	0.9145	0.9023	378	0.8959	0.8811
259	0.9331	0.9237	319	0.9141	0.9020	379	0.8956	0.8807
260	0.9328	0.9234	320	0.9138	0.9016	380	0.8953	0.8804
261	0.9325	0.9230	321	0.9135	0.9012	381	0.8950	0.8800
262	0.9322	0.9226	322	0.9132	0.9009	382	0.8947	0.8797
263	0.9319	0.9223	323	0.9129	0.9005	383	0.8944	0.8793
264	0.9315	0.9219	324	0.9126	0.9002	384	0.8941	0.8790
265	0.9312	0.9215	325	0.9123	0.8998	385	0.8938	0.8736
266	0.9309	0.9212	326	0.9119	0.8994	386	0.8935	0.8783
267	0.9306	0.9208	327	0.9116	0.8991	387	0.8932	0.8779
268	0.9303	0.9204	328	0.9113	0.8987	388	0.8929	0.8776
269	0.9299	0.9201	329	0.9110	0.8984	389	0.8926	0.8772
270	0.9296	0.9197	330	0.9107	0.8980	390	0.8923	0.8769
271	0.9293	0.9193	331	0.9103	0.8977	391	0.8920	0.8766
272	0.9290	0.9190	332	0.9101	0.8973	392	0.8917	0.8762
273	0.9287	0.9186	333	0.9098	0.8969	393	0.8914	0.8759
274	0.9283	0.9182	334	0.9095	0.8966	394	0.8911	0.8755
275	0.9280	0.9179	335	0.9092	0.8962	395	0.8908	0.8752
276	0.9277	0.9175	336	0.9088	0.8959	396	0.8905	0.8748
277	0.9274	0.9171	337	0.9085	0.8955	397	0.8902	0.8745
278	0.9271	0.9168	338	0.9082	0.8952	398	0.8899	0.8741
279	0.9267	0.9164	339	0.9079	0.8948	399	0.8896	0.8738
280	0.9264	0.9160	340	0.9076	0.8945	400	0.8893	0.8734
281	0.9261	0.9157	341	0.9073	0.8941	401	0.8890	0.8731
282	0.9258	0.9153	342	0.9070	0.8938	402	0.8887	0.8727
283	0.9255	0.9149	343	0.9067	0.8934	403	0.8884	0.8724
284	0.9252	0.9146	344	0.9064	0.8930	404	0.8881	0.8720
285	0.9248	0.9142	345	0.9061	0.8927	405	0.8878	0.8717
286	0.9245	0.9139	346	0.9057	0.8923	406	0.8875	0.8714
287	0.9242	0.9135	347	0.9054	0.8920	407	0.8872	0.8710
288	0.9239	0.9131	348	0.9051	0.8916	408	0.8869	0.8707
289	0.9236	0.9128	349	0.9048	0.8913	409	0.8866	0.8703

Note: For explanation and example of use of the volume correction factors, see Sheet 3, P 213.2, and for additional information about the groups, see Sheet 5, P 213.2. The first two sheets of this series of tables were published in the January, 1946 issue of The Petroleum Engineer.

I've found the cement that's a bear for a "Squeeze"!

OIL MEN have learned to depend on Unaflo—the cement with the delayed, the postponed, the *retarded* set. They use it reguarly to assure the success of squeeze jobs. For it does not stiffen or congeal prematurely. After the squeeze, excess Unaflo slurry—still pumpable—is reversed out with ease.

Unaflo is used on other jobs, too. Its *retarded* set keeps it fluid during the cementing operation—provides an extra margin of safety in the event of unforeseen delays.

Send for "Unaflo Oil-Well Tables," a shirt-pocket booklet of down-the-well volumes of cement and mud. Write to Universal Atlas Cement Company (United States Steel Corporation Subsidiary), Amicable Building, Waco; Oklahoma City; Birmingham; Chicago; New York. Export Distributors, United States Steel Export Company, New York.

PE-U-65

Unaflo *Retarded* Cement
Resistant to Sulfate Waters
Atlas Portland Cement—Type I
Atlas Portland Cement—Type II
Resistant to Sulfate Waters
Atlas High-Early Cement—Type III

UNIVERSAL ATLAS CEMENT COMPANY

SUNDAY EVENINGS—American Broadcasting Company (Blue) Network—U. S. Steel's "The Theatre Guild on the Air"

VOLUME CORRECTION FACTORS FOR PETROLEUM OILS

Observed temp., °F.	6 deg. API 1.0291 sp.gr. Group 0 or H	22 deg. API 0.9218 sp.gr. Group 1 or G	Observed temp., °F.	6 deg. API 1.0291 sp.gr. Group 0 or H	22 deg. API 0.9218 sp.gr. Group 1 or G	Observed temp., °F.	6 deg. API 1.0291 sp.gr. Group 0 or H	22 deg. API 0.9218 sp.gr. Group 1 or G
410	0.8863	0.8700	440	0.8773	0.8597	470	0.8685	0.8496
411	0.8860	0.8696	441	0.8770	0.8594	471	0.8682	0.8493
412	0.8857	0.8693	442	0.8767	0.8590	472	0.8679	0.8489
413	0.8854	0.8689	443	0.8764	0.8587	473	0.8676	0.8486
414	0.8851	0.8686	444	0.8762	0.8584	474	0.8673	0.8482
415	0.8848	0.8683	445	0.8759	0.8580	475	0.8671	0.8479
416	0.8845	0.8679	446	0.8756	0.8577	476	0.8668	0.8476
417	0.8842	0.8676	447	0.8753	0.8573	477	0.8665	0.8472
418	0.8839	0.8672	448	0.8750	0.8570	478	0.8662	0.8469
419	0.8836	0.8669	449	0.8747	0.8567	479	0.8659	0.8466
420	0.8833	0.8665	450	0.8744	0.8563	480	0.8656	0.8462
421	0.8830	0.8662	451	0.8741	0.8560	481	0.8653	0.8459
422	0.8827	0.8659	452	0.8738	0.8557	482	0.8650	0.8456
423	0.8824	0.8655	453	0.8735	0.8553	483	0.8647	0.8452
424	0.8821	0.8652	454	0.8732	0.8550	484	0.8644	0.8449
425	0.8818	0.8648	455	0.8729	0.8546	485	0.8642	0.8446
426	0.8815	0.8645	456	0.8726	0.8543	486	0.8639	0.8442
427	0.8812	0.8641	457	0.8723	0.8540	487	0.8636	0.8439
428	0.8809	0.8638	458	0.8720	0.8536	488	0.8633	0.8436
429	0.8806	0.8635	459	0.8717	0.8533	489	0.8630	0.8432
430	0.8803	0.8631	460	0.8714	0.8530	490	0.8627	0.8429
431	0.8800	0.8628	461	0.8711	0.8526	491	0.8624	0.8426
432	0.8797	0.8624	462	0.8709	0.8523	492	0.8621	0.8422
433	0.8794	0.8621	463	0.8706	0.8519	493	0.8618	0.8419
434	0.8791	0.8618	464	0.8703	0.8516	494	0.8615	0.8416
435	0.8788	0.8614	465	0.8700	0.8513	495	0.8613	0.8413
436	0.8785	0.8611	466	0.8697	0.8509	496	0.8610	0.8409
437	0.8782	0.8607	467	0.8694	0.8506	497	0.8607	0.8406
438	0.8779	0.8604	468	0.8691	0.8503	498	0.8604	0.8403
439	0.8776	0.8601	469	0.8688	0.8499	499	0.8601	0.8399
						500	0.8598	0 8396

Explanation of the Groups: The coefficients of expansion, corresponding degrees API and specific gravity, and the range of the groups are shown below:

Coefficient of expansion at 60 °F.	Corresponding		Group		Range of the groups	
	deg. API	Specific gravity	*Number	**Letter	deg. API at 60° F.	Specific gravity at 60 °F.
0.00035	6	1.0291	0	H	Up to 14.9	1.0760 to 0.9660
0.00040	22	0.9218	1	G	15.0 to 34.9	0.9659 to 0.8499
0.00050	44	0.8063	2	F	35.0 to 50.9	0.8498 to 0.7754
0.00060	58	0.7467	3†	E†	51.0 to 68.9	0.7753 to 0.7239
0.00070	72	0.6953	4	D	64.0 to 78.9	0.7238 to 0.6723
0.00080	86	0.6506	5	C	79.0 to 88.9	0.6722 to 0.6418
0.00085	91	0.6360	6	B	89.0 to 93.9	0.6417 to 0.6276
0.00090	97	0.6193	7	A	94.0 to 99.9	0.6275 to 0.6115

*Designations adopted by the U. S. Bureau of Standards.

**Designations adopted by the Institute of Petroleum, London.

Note: For explanation and example of the use of the volume correction factors, see Sheet 3, P 213.2, and for the first two sheets of this series of tables, see the January, 1946, issue of The Petroleum Engineer.

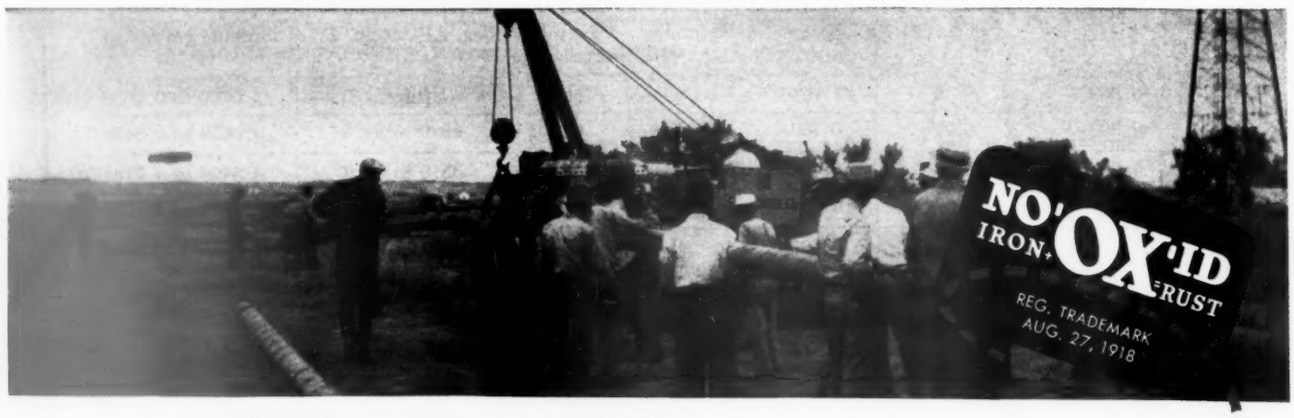
†All motor fuel blends of gasoline and benzol shall be considered as falling in Group 3 or E.

● The oil and gas industries find satisfaction in the announcement that NO-OX-IDized wrapper is again available for civilian jobs . . . and the protection of lines that carry gas and oil to America's millions.

For over a quarter century, NO-OX-IDixed wrapper, used in conjunction with NO-OX-ID, the *original* rust preventive, has kept corrosion from pipe lines laid through salt water, swamps, acid-polluted streams, alkaline desert tracts, and highly corrosive soils.

The NO-OX-ID combination guards pipe lines four ways: 1 . . . insulates against electrical effects; 2 . . . resists soil action; 3 . . . repels moisture; 4 . . . stops underfilm corrosion that may already be present.

The Dearborn service engineer near you will be glad to give complete details as to proper applications and lasting protection for *your* lines.



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Running Tour WITH MEN IN THE INDUSTRY

● **R. C. Walker,** president of Aireon Manufacturing Corporation, has announced the election of **Arthur E. Welch** to fill the newly created postwar office of vice president in charge of sales. Welch formerly was vice president and treasurer.

● **Jack Edwards,** vice-president and sales manager for Oil City Tool Company, Houston, Texas, arrived in Caracas, Venezuela, January 13. While in South America, Edwards expects to visit fields in Eastern and Western Venezuela and Colombia.

Jack Edwards

● **Walter F. Nicoden** has been appointed assistant general superintendent of Edgar Thomson Works, Carnegie-Illinois Steel Corporation, U. S. Steel subsidiary. He is succeeding **John Lloyd,** who retired December 31.

● **Harvey A. Craig** has been appointed as Pacific Coast manager of Republic Steel Corporation, it has been announced by **J. M. Schlendorf,** vice president in charge of sales.

In this new post, created to bring under one head the many sales problems peculiar to the coast, Craig will supervise the territory served by all 3 coast sales offices. He will, however, retain his position as manager of the Los Angeles office. No change is being made in the personnel of the other offices. **W. L. Thoma** is district sales manager of the San Francisco office; and **C. V. Gardner** is district sales manager of the Seattle office.

● **Major Jack I. Laudermilk,** returning to civilian life after more than 4 years' service in the army, has accepted the position of head of the department of Petroleum Engineering at New Mexico School of Mines. He served overseas as an intelligence officer in the field artillery and is a veteran of the battles of the Ardennes, Northern France, Rhineland, and Central Europe. After V-E Day he was military summary court officer of the city of Nordlingen, Germany, with the Army of Occupation. Major Laudermilk is a registered professional engineer. Prior to the war he was a faculty member of the University of Texas, preceding which he was in the oil industry in the Mid-Continent area.

Jack I. Laudermilk

● **Louis M. Funderburg,** general operating manager, has been elected vice president of Universal Atlas Cement Company. He will be in general charge of manufacturing operations for this U. S. Steel Corporation subsidiary.

● **William G. Shipman** has recently been appointed by the Graver Tank and Manufacturing Company, Inc., as plant superintendent at East Chicago, Indiana. Holder of a degree in mechanical engineering from Cornell University, Shipman was associated with Babcock and Wilcox for a period of 10 years as engineer and plant manager and later with the Allied Chemical Corporation on steel plate work.

His other plant supervisory experience includes two year periods each with the Firestone Tire and Rubber Corporation and the General Motors Corporation.

● **E. B. Pool,** for 10 years a mechanical and experimental engineer with Chrysler Corporation, has been appointed to conduct a new type of valve research work by Edward Valves, Inc., East Chicago, Indiana. The appointment was announced by **L. H. Carr,** Edward director of research. Pool will specialize in stress and strain experiments and pioneering investigations in flow characteristics and pressure drop in addition to other mechanical and metallurgical research work. During the war he was in charge of the physical testing laboratories and material and process standards at the Dodge-Chicago plant, operated by Chrysler. He is a graduate of Princeton University.

E. B. Pool

● **Robert S. Hatch** has been appointed manager of the purchasing department of The Texas Company, succeeding **Greer W. Orton,** who has become assistant to the president, it was announced by **Harry T. Klein,** president. Hatch has been with Texaco since 1927, and has been a member of the purchasing department since 1938.

● **F. W. Oudt** has been transferred from Saginaw, Michigan, to Houston and promoted to senior geophysicist for the Shell Oil Company. At Saginaw Oudt was chief seismologist for the Michigan division of Shell's Mid-Continent area.

● **W. I. ("Ike") West** has been transferred from Houston, Texas, to Mid-Continent Supply Company's division offices in the Petroleum Building, Midland, Texas, where, as division manager, he is in charge of the company's extensive operations in the West Texas-New Mexico territory.

● **Arthur L. Morrison,** recently discharged veteran, has been appointed sales engineer of the Gaso Pump and Burner Manufacuring Company, with headquarters in Dallas, it is announced by **H. F. Stover, executive** vice president of the company.

Morrison joined the Gaso organization in 1940, after being graduated from Oklahoma University. Entering the service in March, 1943, he was a flying instructor until March, 1945, when he began training as a fighter pilot. He was discharged in September, 1945, and rejoined the Gaso company a month later.

Arthur L. Morrison

● **W. A. Finn** has been appointed export manager of Worthington Pump and Machinery Corporation, having just been released from the U. S. Navy. Finn succeeds **George Gellhorn** who has accepted a position of general manager of C. E. Halaby, one of the Worthington's industrial machinery dealers in Colombia, South America. Before the war, Finn was manager of Worthington's Boston district office. His new headquarters will be in Harrison, New Jersey.

● **E. Hastings Ackley,** patent and legal attorney for Otis Pressure Control, Inc., and Otis Engineering Corporation, has announced the opening of private offices in Dallas.

● **Philip S. Magruder,** manager of manufacturing of General Petroleum Corporation, has been elected vice president of the company. The announcement was made in Los Angeles by **S. J. Dickey,** president.

Magruder joined General in 1925 as gas tester. Soon he was promoted to gas engineer, and later to superintendency of the gas department. In 1942 he was advanced to manager of that department. Last fall he was elected to the board of directors and appointed head of the manufacturing department, which position he still holds.

P. S. Magruder

● **Louis D. Mann,** who has acted as manager of the government-owned Maumelle Ordnance Works at Little Rock, Arkansas, has been appointed vice president and general manager of the Cities Service Refining Corporation at Lake

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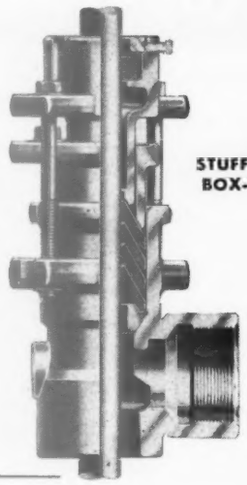

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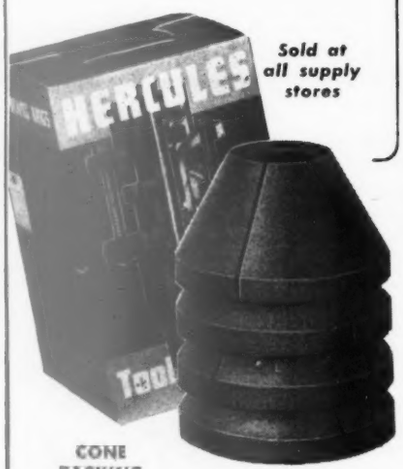

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Charles, Louisiana. **William W. Lowe,** former general manager of the Lake Charles refinery, is being transferred to New York where he will join the staff of Petroleum Advisers, Inc. **G. L. Mateer,** former general superintendent at Lake Charles, also is being transferred to New York as technical director of manufacturing operations in the Petroleum Advisers group.

Roland A. Sherwood

● **Roland A. Sherwood** has been appointed assistant to the president of American Locomotive Company, it has been announced by **Robert B. McColl,** president. Sherwood joined the locomotive company in 1939 and became assistant to the executive vice president last September. He will make his headquarters at the company's general offices at 30 Church Street, New York.

● **C. M. Vardaman,** district superintendent of the production department, Humble Oil and Refining Company, has been transferred from the Talco, Texas, district to the Stratton district, Kingsville, Texas. **Henry W. Roberson,** assistand district superintendent, Pickton, Texas, was promoted to district superintendent and transferred to Navarro Crossing district. **V. O. Harris** was promoted to Talco district superintendent. **James H. Galloway,** returned from military leave, and was transferred from the Kelsey district, Santa Elena, Texas, to the Sullivan district, Encino, Texas, as district superintendent. **Oliver L. Furse,** district petroleum engineer, Hobbs, New Mexico, was transferred to the Pickton, Texas, district, as assistant superintendent. **William A. Castille** was appointed assistant division civil engineer for the Louisiana division, New Orleans, Louisiana. **Murray A. Cunningham,** district civil engineer, Natchez, Mississippi, district, returned from military leave. **John S. Hacker** was promoted to district civil engineer, North Crowley district, Crowley, Louisiana. **Bailey S. Hyden** was promoted to district civil engineer, Lovell Lake district, Beaumont, Texas. **William E. Neill** was promoted to district civil engineer, Paradis, Louisiana, district. **Charles E. Ullrich,** civil engineer, Katy gas plant, Katy, Texas, was transferred to the North Katy district, as district civil engineer. **Don F. Shaw,** district petroleum engineer, returned from military leave and was transferred from the Government Wells district, Freer, Texas, to the Flour Bluff district, Corpus Christi, Texas. **Tom E. Beaird, Jr.,** petroleum engineer, East Texas division office, Tyler, Texas, was transferred to the Navarro Crossing district, Palestine, Texas, and promoted to district petroleum engineer. **Harold M. Davidson,** assistant district chief clerk, Talco, Texas, district, was transferred to the Navarro Crossing district, and promoted to district chief clerk.

Ray G. Noble

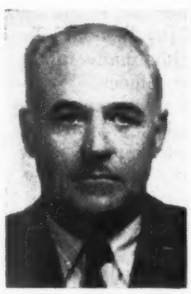
● **Ray G. Noble** has returned to his old duties as advertising manager for the Union Wire Rope Corporation after 3 years' service with the U. S. Army. Ray had been with the wire rope corporation 5 years before his entrance into armed service.

● **C. E. Finney, Jr.,** assistant vice president of Standard of California, was elected a vice president of the company. His election was announced by **R. G. Follis,** president of the oil company.

● **Clay Briggs,** chief engineer, Cities Service Oil Company, Bartlesville, Oklahoma, has been elected to the board of directors of Cities Service Oil Company, (Delaware). Briggs also is a member of the board of directors of the Empire Pipeline Company.

● **Raymond W. Parker** has been appointed chief engineer of Standard of California's manufacturing department. Parker, a graduate in engineering from the University of British Columbia, started with Standard in the engineering department at the company's El Segundo refinery and progressed through posts of increasing importance, both at El Segundo and Richmond refineries. In 1943 he became assistant chief engineer in the manufacturing department's San Francisco headquarters.

● **Edward D. Lynton** has been given leave of absence at the request of the Minister of Industrial Production for the French Government at Paris, by the Standard Oil Company of California, to accept a temporary assignment as oil consultant to the French people. Ted, with Mrs. Lynton and their 14 year old son, Dennis, are now on their way overseas, and are looking forward to an interesting time in the European capital. Ted is a long time member of the AAPG and is widely known among western oil men.



Edward D. Lynton

● **David E. Harris,** vice president, General Electric Supply Corporation, San Francisco, has been selected to receive the 1945 Medal for Cooperation given under the James H. McGraw Award, it has been announced by George C. Tenney, president, McGraw Hill Company of California.

● **A. E. Fisher,** petroleum engineer in the production department of Stanolind Oil and Gas Company, Odessa, Texas, was elected chairman of the Permian Basin section of AIME at a meeting on January 29 at the Scharbauer Hotel, Midland, Texas. **Lee Flood,** chair-

BUILDING...
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After war's final "cease-firing", look for the building industry to go places . . . for vast cities-within-cities to take shape. They're on drafting boards today.

Air conditioning and ventilating will be widened to include removal of dust, bacteria and odors from the atmosphere by unit-type air sanitation equipment. On the upswing will be radiant heating, zoned heating, service hot water, spot cooling units . . . gas air conditioning which regulates humidity . . . a single heat pump system which heats buildings or cools them as desired.

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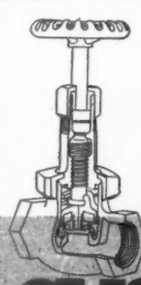
Whether it's a small bronze valve or a huge iron body gate valve with a 24-inch opening the name Fairbanks stands for sound engineering, careful chemical and metallurgical control of alloys, ample metal for the job. The full line is given in catalog "42" which will be sent you if you ask for it. If you need special assistance with individual problems of valve selection and application, call on the facilities of the Fairbanks Engineering Department.



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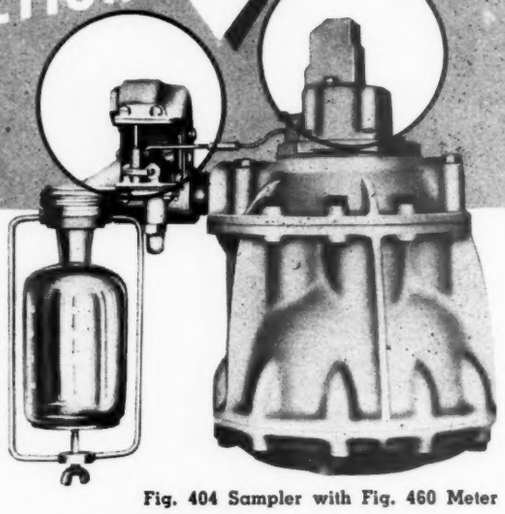

Fig. 404 Sampler with Fig. 460 Meter

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The Fig. 404 Automatic Sampler makes it easy to evaluate the QUALITY of each well's output by furnishing a true proportional sample.

This is the only efficient, economical basis for payment of royalties and taxes, analyses of control and operating expense, and quick, unfailing detection of sleepers or wet wells.

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Similar in measuring principle to the famous Bowser Xacto Meter—but designed especially for the strenuous service encountered in oil fields—the Fig. 460 Positive Displacement Meter accurately records individual well production.

It provides an indisputable record for royalties and taxes . . . eliminates gauge tanks and piping . . . prevents evaporation due to weathering . . . reduces fire and other hazards.

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man of the Goldsmith Operators Engineering Committee, was elected vice chairman of the section. **S. V. McCollum,** division petroleum engineer of Continental Oil Company at Midland, was elected secretary-treasurer. The Permian Basin section of the AIME succeeds the Permian Basin Engineering Association.

● **A. J. Penick,** recently elected chairman of the board of directors, Oil Center Tool Company, Houston, Texas, takes a keen interest in watching his company's equipment perform in the field. On a recent trip to the Lake Creek, Texas, field

to observe "triple-completion" operations that utilize a new style heavy-duty packer and surface equipment of his own design, Penick posed with Oil Center sales engineer, **Ace Elliott,** in the shadow of a big 10,000-lb. test O-C-T tree.

● **Clyde T. Foster** has been elected a vice president of The Standard Oil Company (Ohio), according to announcement by **W. T. Holliday,** president. In 1929 Foster joined Standard as special assistant to the sales manager and successively held the positions of manager of the service station department, manager of the operating department of the sales department, and in 1942 was made assistant to the president. A year later he was given the additional duties of director of industrial relations. Last August he was relieved of these duties and, while continuing as assistant to the president, assumed the duties of **William J. Semple,** vice president and treasurer, during the latter's absence on account of illness.

Clyde T. Foster

● **Rex L. Smith** has returned to Shell Oil Company after almost 5 years in the armed forces. Since 1931 Smith has been in El Dorado, Kansas, with the pipe line

department. He returns from the army to take up the duties of assistant manager of the pipe line and crude oil purchasing departments and will have his headquarters on the eighth floor of the Skelly Building, Tulsa.

● **Norman J. McGaw** has been appointed a general vice president of Shell Oil Company, Inc., for east of the Rocky Mountain territory, according to an announcement at the company's New York offices. McGaw joined Shell in 1925, and after seeing service with the company in various departments, he was named vice president in charge of transportation and supplies in 1939. The transportation and supplies activities of Shell's east of the Rocky Mountains territory, formerly under the supervision of McGaw, will now be directed by **D. B. Hodges**, general manager of the department.

Norman J. McGaw

● **J. M. Wherritt** has been named manager of the new emergency communications division of the Aireon Manufacturing Corporation, according to **R. C. Walker**, president of the company. He joins Aireon after 14 years with the Missouri State Highway Patrol where he headed the communications division. Wherritt held a commission as captain with the Missouri Patrol.

● **Frank W. Evans** has rejoined the Shell Oil Company at Houston as senior geologist after more than 3 years' service with the U. S. Navy. Evans has been with Shell since 1927 and was a research geologist at Houston when he entered the Navy as a lieutenant, senior grade, in September, 1942.

● **Robert L. Featherly,** recently released from the United States Navy and formerly employed by the engineering department of The Dow Chemical Company, has returned to Dow as a member of the magnesium sales staff on cathodic protection.

● **George L. Nye,** a professional petroleum engineer and geologist, was elected vice president of the City National Bank at the annual director's meeting, January 17. For the last year he has been in charge of the bank's oil and gas department.

● **C. L. Gould** has been placed in charge of the new San Francisco office of the Roto Division of Elliott Company, manufacturers of tube cleaners. The office is at 526 Folsom Street. Gould, who has been with the company for more than 10 years, was previously in charge of the New Jersey district.

● **George Mason** has been appointed director of information of the American Locomotive Company, 30 Church Street, New York, according to a company announcement.

● **James R. Downing** has been appointed director of research at Cook Electric Company, Chicago, Illinois.

O. F. Moore

Charles Bunje, Jr.

● **O. D. Donnell,** president, the Ohio Oil Company, has announced that effective February 1, **Charles Bunje, Jr.,** retired as vice president and manager of the pipe line department under the company's retirement plan, after having completed 39 years' continuous service. **O. F. Moore,** who has been assistant manager of the pipe line department and assistant secretary of the company, has been elected a vice president and made manager of the pipe line department succeeding Bunje.

● **Harry H. Power,** chairman of the petroleum engineering department of the University of Texas, gave an illustrated talk about his recent 3 month's trip to Venezuela at the annual meeting of the North Texas Section of the AIME at Fort Worth, Texas, on January 24.

● **Ralph D. Curtis** has resigned from the Barnsdall Oil Company to join Earlougher Engineering (petroleum consultants and core analysis) of Tulsa as valuation-appraisal and pressure maintenance engineer.

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COMPLETE FIELD EQUIPMENT FOR SEISMIC EXPLORATION
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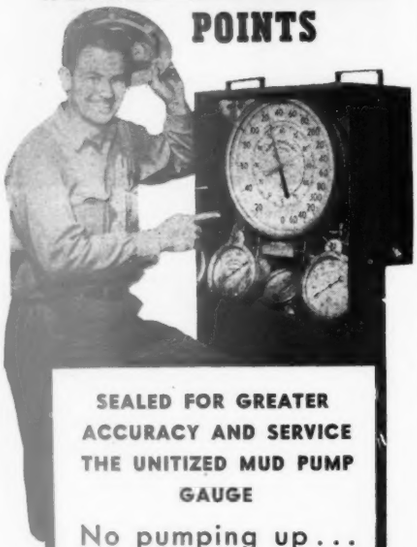

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No pumping up . . . no adjusting . . . no leaks. Fluid system is factory loaded and permanently sealed—fluid remains in unit even during transportation and storage. Fast, foolproof installation — guaranteed accuracy.

Accuracy, sensitivity and smooth, easy readings make the unitized the ideal portable gauge for measuring slush pump pressures. Mechanism runs in an oil bath, eliminating rust or corrosion. Large numerals stand out clearly from 30 feet or more, and readings can be made by simply noting position of gauge hand. Vernier retard movement covers both low and high pressure ranges. Unitized is available in one, three or five thousand pound capacities.

MARTIN-DECKER CORP.
LONG BEACH, CALIFORNIA
T. J. Cullen, Bakersfield, California
Reed Roller Bit Co., Houston, Texas

LAUGH WITH BARNEY

"What happened?" asked the new mother as she recovered from the anesthetic in the delivery room.

"Twins," replied the father.

"Oh, Boy! Twenty more pounds of sugar."

* * *

A traveling man's wife may be showing her love when she accompanies her husband down to the station to see him off, and then on the other hand, she may just be making sure he's leaving town.

* * *

"How was your date last night?"

"Well, frankly he was kind of trying at times."

"Huh, mine was trying all the time."

* * *

"All right back there?" shouted the bus driver.

"No. Wait 'til I get my clothes on!" replied a feminine voice.

So the driver led the stampede to the rear and watched a girl get on with a basket of laundry.

* * *

A pink elephant, a green rat, and a yellow snake walked into a cocktail bar. The bartender looked up, glanced at his watch and said, "You're a little early, boys—the convention hasn't started yet."

* * *

A friend of ours has changed from violin playing to piano playing, because a glass of beer won't stay on his violin.

* * *

A group of elephant hunters were talking things over at their Lunnon club. They decided to ask a very quiet member, who rarely spoke to his colleagues, but who was known to be the world's champion elephant hunter, exactly how he did it. "I say, old boy," said their spokesman to the man, "would you mind revealing your hunting secrets. Do you use deep pits, decoys, or what?"

"Oh, no," said the successful one. "It's much simpler than that. All I need is a blackboard and easel, a bit of chalk, a spyglass, a Mason jar, and a pair of tweezers."

"I beg your pardon, sir," cried the fellow members, "you can't catch elephants with that equipment."

"Oh yes I can," was the retort. "I set up my blackboard, write on it two plus two are five. An elephant comes along, and, being a sociable sort of animal, goes and fetches other elephants to come and share the joke. There I am, sitting up a tree, and there are all the elephants standing around the blackboard, laughing their fool heads off. I look at them through the wrong end of the spyglass, which makes them very small. Then I pick them up with the tweezers, pop them into the jar, and there you are!"

* * *

They were talking about the difference between men and women. "Now take letter writing, for instance," he said, "you women can never write a letter without a P.S."

"Do not be ridiculous," she scoffed right back. "I will write you next week and let you see."

The letter came as promised, and at the end of it was written: "P.S.—What did I tell you?"

* * *

A drilling contractor had lost his wallet. A few days later he received this letter: "Sir: I foun yor mony. Remorz is nawing me, so ahm sendin sum of it bak. When it naws me agin, I will sen sum more."

A Hollywood producer called a conference of his writers to discuss the title for his new production, to be called "The Optimist." "Gentlemen," he said, "I'm afraid we must change the title to something simpler. You know and I know what an optimist is, but how many of the morons who are going to see the picture know that an optimist is an eye-doctor?"

* * *

The big movie star flung a $100 bill on the waiter's tray when he brought the Scotch and soda, and cried impressively so all could hear, "There, my good man! Get something for yourself!"

The waiter returned later with the change, which was only $5.25. "What's the big idea?" asked the movie star. "I only had one drink. I gave you a hundred dollar bill!"

"But you told me to get something for myself."

"I know—what did you get?"

"An overcoat."

* * *

It seems that war bonds weren't selling too well a few years back to the up-New York State farmers. So ex-Gov. Lehman set out to peddle them himself. He motored into the sticks and came on a farmer leaning on a hoe. "Hi," cried the Governor, "ever hear of Herbert Lehman of Albany?"

"Nope," the indifferent reply came.

"Ever hear of Franklin Roosevelt?"

"Nope."

"Pearl Harbor?"

"No idea who she is."

"Surely then you heard of Churchill?"

"Cain't say as I have, stranger—what of it?"

"Well," said Lehman, "I'm here to see you about a bond."

"Ain't interested," said the farmer briefly, and he turned and entered the house.

The farmer's wife, who had been watching through the curtains, greeted her husband with: "Who was it? What'd he want?"

"Oh," said the farmer, sucking his teeth triumphantly, "some city slicker from Albany named Lehman told me about a feller named Rosivelt who got in trouble with a gal called Pearl Harbor from some place near Church Hill. He wanted me to go his bond—but I turned him down flat. You gotta git up early to fool me."

* * *

The farm boy stepped starry-eyed into an auto agency showroom. "How long would it take to pay for this one," he asked, pointing to a snappy open job, "on installments."

"That'd depend on how much you could afford each month, sir," replied the salesman cautiously.

"Well, I guess I could manage three dollars a month."

The salesman blinked. "Three dollars a month!" he laughed. "It'd take you a hundred years!"

The prospective purchaser gazed steadfastly at the model and said: "So what? It's worth it!"

* * *

A friend of ours was called to the telephone on his birthday last year just before V-E Day and to his amazement heard a voice announce and sing a singing telegram: "Happy Birthday to You!"

"I thought singing telegrams were forbidden," he said. "How come?"

The singer grew very cautious over the phone: "Black market!"

THE BAKER PORTABLE HYDRAULIC KELLY AND PIPE STRAIGHTENER

which utilizes the principle of the hydraulic ram, applying the force built up by a manually operated pump to the bend or kink in the Kelly, drill pipe, or drill collar. It is readily portable (the entire unit weighing only 1,200 pounds) and is brought to the rig on any small pick-up truck or trailer. It is quickly set up on the rotary table by using the cat line, and the straightening is done with the Kelly, or pipe, hanging in its normal position.

DON'T LOSE TIME AND CAUSE MORE KINKS HAULING A KELLY AROUND

Probably more Kellys are bent during transportation, and in being laid down and picked up, than from any other cause. Frequently a Kelly that has just been straightened in the shop will again be bent while taking it back to the well, rolling it off the truck, and dragging it into the rig. — It is much faster, easier and safer to take the Baker Kelly Straightener to the well. On isolated locations, or in foreign fields, it is almost indispensable.

POWERFUL AND LONG LASTING

Force sufficient to straighten 8¾" diameter drill collars can be built up readily by manual operation of the pump, which develops 95 tons pressure. It is ruggedly built and safe to use. The only parts subjected to wear are inexpensive and easily replaceable. The body and pump will last indefinitely.

YOU REALLY NEED ONE

if you are drilling oil or gas wells, because bent or kinked Kellys and drill pipe are a definite hazard. The Baker **PORTABLE** Kelly Straightener makes it so easy and so safe to straighten them that there is no reason to "take chances." — Ask any Baker office or representative for details and prices.

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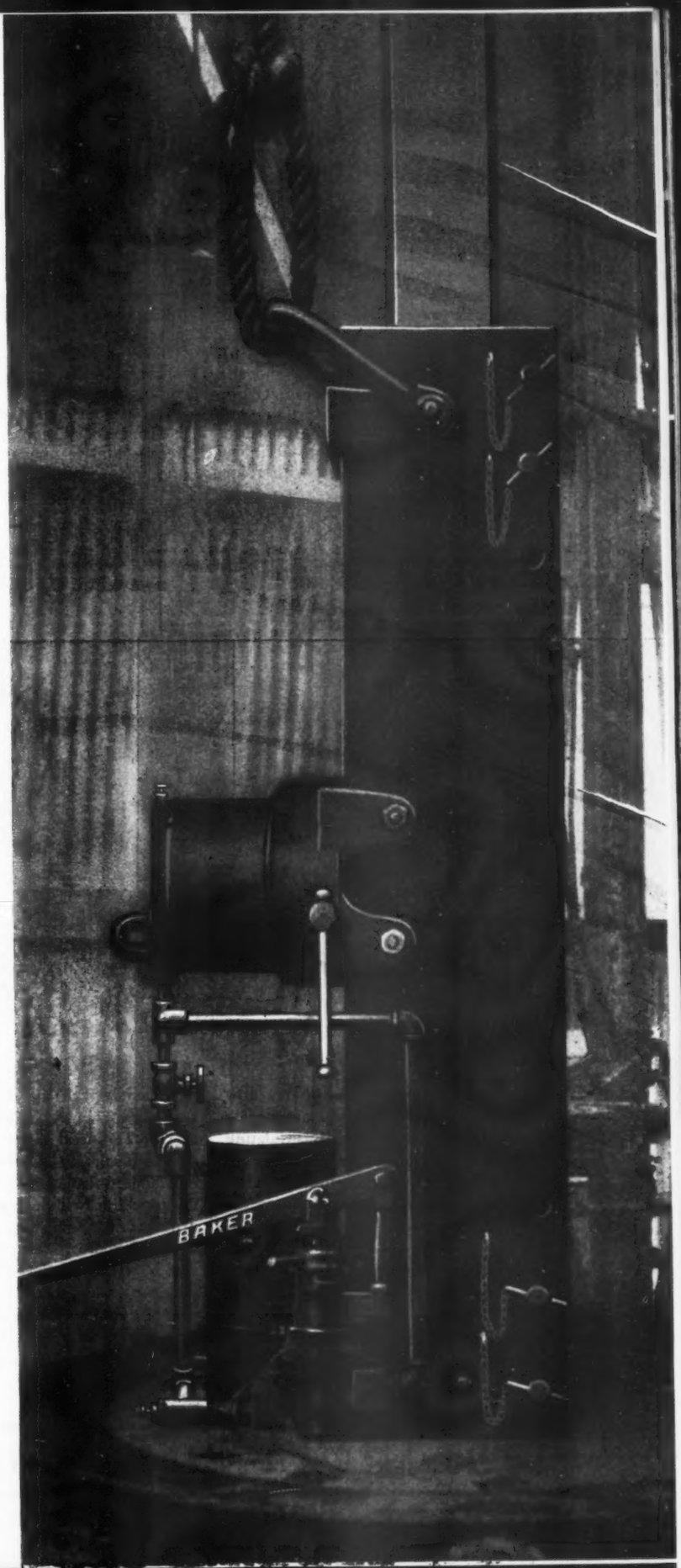

BAKER KELLY STRAIGHTENER

WPRA technical program

The arrangements for the technical program for the Western Petroleum Refiners Association's 34th annual meeting, to be held in Fort Worth, Texas, at the Blackstone Hotel, March 25, 26, and 27, have been completed.

Interesting speakers have been obtained who will present papers on such subjects as catalytic cracking for the medium and small refiners, by the Universal Oil Products Company and the Houdry Process Corporation. Other papers will be presented dealing with crude oil desalting by heat and pressure, and metallurgy as applied to stainless steels and alloys associated with refining operations. The exact titles of the papers and names of the speakers will be announced at a later date.

The first technical session will begin at 9:30 a. m. on Tuesday, March 26, in the ballroom of the Blackstone Hotel.

In addition to the technical meetings, those attending will have an opportunity to hear a prominent speaker who was a member of a petroleum mission to Japan, discuss the Japanese oil installations. Other speakers will discuss taxes and other subjects of timely interest to the refining industry.

Names representatives

Hunt Tool Company is now acting as representative for sales and services for the Foster Cathead Company in the Gulf Coast area. All sales will be made through regular oil field supply stores.

Tillery and McLendon, working out of Texas Flange Company, Odessa, Texas, will represent them in the same capacity in West Texas and New Mexico.

AREA SUPERINTENDENT
Graduate Petroleum Engineer. Administrative background and complete experience exploratory wells. Location Eastern Venezuela. Experienced in foreign countries and knowledge of Spanish preferred. Write giving full particulars of education and experience.
THE ATLANTIC REFINING CO.
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POSITION WANTED AS SALES REPRESENTATIVE FOR ASPHALTS AND ROAD OILS in the State of Wisconsin. Have had several years experience in the BITUMINOUS Road construction business. Address Box 43, c/o *The Petroleum Engineer,* P. O. Box 1589, Dallas, Texas.

WANTED: Sales Engineer by oilfield engine distributor. Engineering graduate with thorough knowledge of East Texas oil field. Address Box No. 44, c/o *The Petroleum Engineer,* P. O. Box 1589, Dallas, Texas.

WANTED—Sales manager experienced in process equipment for liquids and water treating equipment. Location middle west. Write giving age, education, experience, positions held, companies employed by, references. Salary expected. Enclose picture. Address Box 45, c/o *The Petroleum Engineer,* P. O. Box 1589, Dallas, Texas.

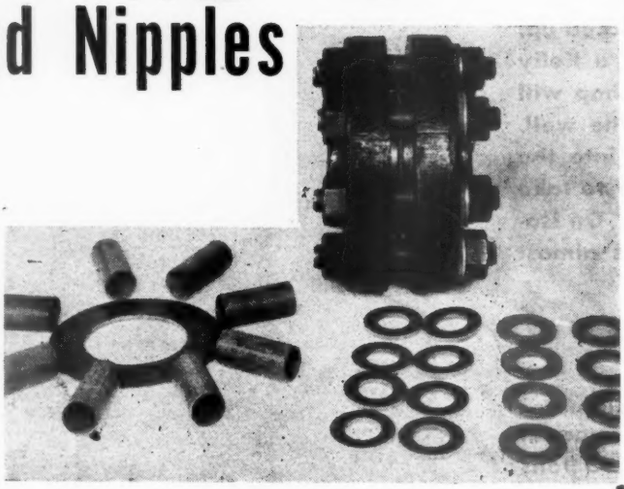
ENGINEERS WANTED
An oil field service organization has openings for engineers in technical oil field service. Men with one or two years experience in oil production and degree in Petroleum, Electrical or Mechanical Engineering are given preference. Permanent position with long established company. Write giving full details on education, experience, age and marital status. Attach small photograph. Address replies to Box 38, care of *The Petroleum Engineer,* P. O. Box 1589, Dallas, Texas.

WANTED—Director of research and development. Executive with ability to take full charge of all research developing and engineering. Must be familiar with oil refineries, chemical equipment and construction, general plate construction, general process equipment. Location mid-west. Write, stating experience, education, age, companies worked for, positions held, salary expected, references. Enclose picture. Address Box 42, care *The Petroleum Engineer,* P. O. Box 1589, Dallas, Texas.

WANTED—District sales manager water treating and process equipment for liquids. Must be familiar with these lines and have held similar positions. Location, New York City. Write, giving experience, education, age, companies worked for, references, positions held, salary expected, etc. Address Box 41, care *The Petroleum Engineer,* P. O. Box 1589 ,Dallas, Texas.

MANUFACTURERS REPRESENTATIVE
Pumps, Valves and Industrial Hose
Wanted by Manufacturers of Industrial Oils
Active organization established in 1921 with highest credit rating and excellent standing desires exclusive selling arrangement commission basis for St. Louis Area. We have experienced equipment sales engineers on our staff. Address Box 46, c/o The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

Insulated Flanges and Nipples



Insulated Flanges break up the flow of stray and galvanic currents in the pipe line by electrically insulating sections of the line. They provide an insulated joint incorporating mechanical strength with the high electrical insulating properties of bakelite, which is not affected by heat, oil or acids. Easily installed, they can be effectively used on pipe lines having cathodic protections.

Insulating Flange consists of two standard forged steel flanges, either of "slip-on" or "butt-weld" types, electrically insulated by bakelite gaskets, washers and tubes. Flanges, studs and nuts meet all A.S.T.M. and A.S.A. requirements Flange Insulating Material can be used on standard flanges already installed in the pipe line without necessitating redrilling of flanges to accommodate bakelite tubing slips. Many pipe line companies are using Phenolic Gaskets in place of metal gaskets, due to the fact Phenolic Gaskets can be repeatedly used over again. Complete data, including specifications and prices furnished; write for Bulletin 230.

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MANUFACTURERS OF:

Explosion Resisting Motor Controls
Junction Boxes and Enclosures
Circuit Breakers and Lighting Panels
Oil Field Motor Controls
Automatic Pipe Line Sampling Devices
Cathodic Protection Equipment
Switchboards
Instrument and Control Panels
Unit Substations

Dolph vice president

P. A. Dolph

Palmer A. Dolph has been elected vice president of Continental Motors Corporation, Detroit, Michigan, to fill the position of assistant sales manager of the automotive and transportation engine division, C. J. Reese, president, announces.

Dolph has been connected with Continental Motors Corporation for 30 years in the production, service, and sales divisions. In recent years he has been middle west district sales manager.

Wyatt representative

J. F. Bechtle

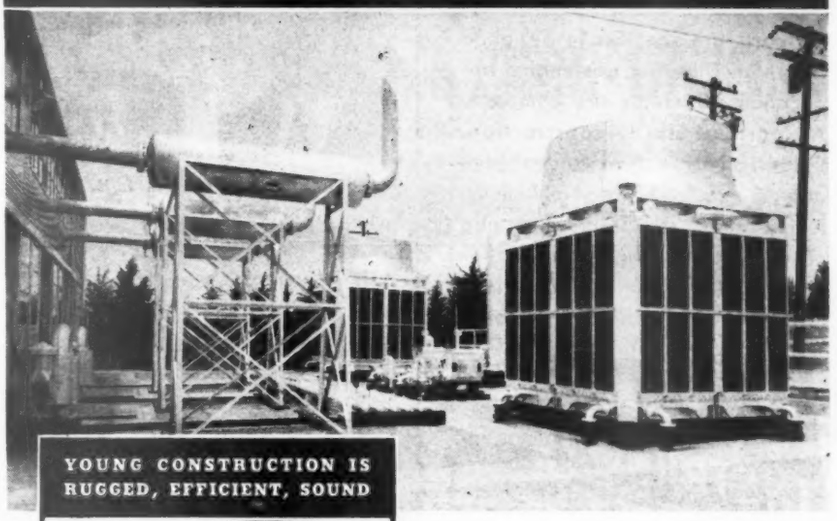
J. F. Bechtle, has been appointed Wyatt Metal and Boiler Works' representative for the New England States comprising New York, Pennsylvania, Delaware, Maryland, and the District of Columbia, with headquarters in New York City.

Bechtle was employed by the M. W. Kellogg Company for a number of years, where he spent considerable time in the metallurgical and research division developing arc-welding methods. He also worked in the estimating and general engineering division, after which he was placed in a managing and executive capacity until he was transferred to the purchasing department. Bechtle left the Kellogg company to become assistant general manager for the Standard Steel Company of California.

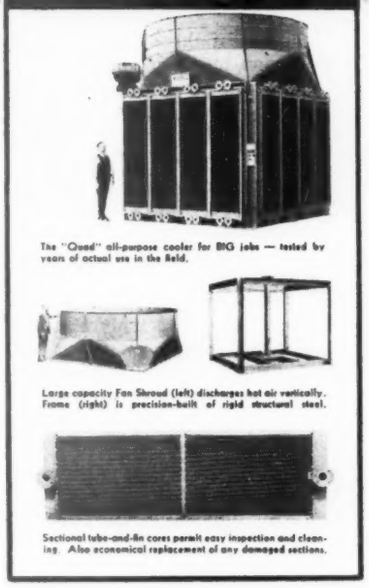
C. W. Doerr promoted

Election of Charles W. Doerr as vice president in charge of erection, American Bridge Company, Pittsburgh, Pennsylvania, has been announced by L. A. Paddock, president of this United States Steel subsidiary. He succeeds Curtis S. Garner, who is retiring after 50 years' service with the company.

INSTALL YOUNG "QUADS"
FOR LOW-COST COOLING AND CONDENSING



YOUNG CONSTRUCTION IS RUGGED, EFFICIENT, SOUND



The "Quad" all-purpose cooler for BIG jobs — tested by years of actual use in the field.

Large capacity Fan Shroud (left) discharges hot air vertically. Frame (right) is precision-built of rigid structural steel.

Sectional tube-and-fin cores permit easy inspection and cleaning. Also economical replacement of any damaged sections.

Young "Quads" are the modern, efficient and economical way for cooling and condensing on BIG jobs. By vertically exhausting hot air, "Quad" units may be installed close together without the interference of air streams. The effect of cross-winds is likewise entirely eliminated. The "Quad" offers high cooling capacity at low-cost operation. Its closed system means no water consumption. Young "Quads" carried a heavy war load . . . were called on for major cooling jobs across the nation. Write for new "Quad" Catalog No. 446.

YOUNG

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Young Quality

CONVECTORS • CONDENSERS EVAPORATORS • AIR CONDITIONING UNITS • HEATING COILS • COOLING COILS • AND A COMPLETE LINE AIRCRAFT HEAT TRANSFER EQUIPMENT.

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THE HAPPY COMPANY, Drawer 770, Tulsa 1, Okla.

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A. R. FLOURNOY COMPANY, 609 S. Grand Ave., Los Angeles, Cal.

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SAFETY CONTROL SYSTEMS
FOR ALL TYPES OF ENGINES

All parts are specifically designed for either Diesel or gas engine applications. Systems are complete. All parts of sturdy construction. Essential protection for engines against excessive water or lube oil temperatures and insufficient lube oil or water pressures. Circuit diagram and installation instructions furnished with each complete unit.

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Roll Out COLLAPSED CASING with the... *Eastman* CASING ROLLER

The Eastman Casing Roller consists of a steel body carrying a number of special alloy steel roller pins so arranged on the tapered body as to enter the collapsed casing without snagging and to provide maximum rolling surface for smooth, effective operation.

The Eastman Casing Roller will save you time and money. For field service, or information, phone

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Caterpillar advancements

L. A. Blanc

W. L. H. Doyle

C. R. Maxwell

C. R. Schad

Promotion of three Caterpillar Tractor Company research projects directors and an assistant engineer to positions as assistant directors of research is announced by C. G. A. Rosen, director of the company's research department.

The newly appointed assistants are: Dr. L. A. Blanc, who will be in charge of physical, chemical, combustion, and metallurgical projects; W. L. H. Doyle, supervisor of special investigations and general research projects including liaison with cooperative and national research activities; C. R. Maxwell, in charge of diesel engine, combustion systems, and fuel injection development projects, and C. R. Schad, in charge of duties of organization, personnel and operational activities.

An expanded postwar program in the field of research, calling for greater flexibility and efficiency, resulted in placing specialists at the head of various research activities, according to Rosen.

J. M. Davies, present assistant to Rosen, will assume added responsibilities including tractor, earth moving, special products, and current product revision projects as well as all field activities.

Marsh anniversary

Organization of the "Marsh Clan" was a feature of the recent celebration of the Jas. P. Marsh Corporation, Chicago, of the 80th anniversary of the founding of this nationally known manufacturer of pressure gages and heating specialties.

The corporation celebrated with a dinner party for all employes who became members of the Clan by virtue of 5 years or more of service.

Oldest employe, Charlie Lubeck, long time foreman of the gage department, who began his 41 years of service about mid-way in the corporation's history, was singled out for special honor. He was presented with a diamond studded Clan pin by Barrett Scudder, president.

Other groups, the 25 year, 20, 15, 10, and 5, each has its distinctive Clan insignia. The 25 year pins are set with a diamond. These were presented as a part of the evening's program, which featured a gourmet's dinner, climaxed by the cutting of the huge 80th anniversary birthday cake decorated with 80 lighted candles. A program of music and novelty acts provided added entertainment.

Macwhyte jubilee

Plans are being formulated for the Macwhyte company to celebrated its fiftieth birthday as a corporation in the near future.

The company from which the present Macwhyte Company has developed was incorporated on February 10, 1896, making this year its golden jubilee. The plans now being formulated provide for several occasions to observe this anniversary.

These will include the annual meeting of employes, officers, and stockholders to be held near the anniversary date. The plans also will provide for a later open house at the plant when both employes of the companies and their families and representatives of the public will be invited to make a tour of the plant. More definite announcement regarding these plans is to be made later.

NORTH TEXAS SECTION AIME OFFICERS. The 1946 officers are, left to right, John H. Murrell, chairman; Roland Gouldy, vice chairman for Wichita Falls; Richard Bright, secretary-treasurer; Barney Fisher, vice chairman for Dallas, and Myer Dubrow, vice chairman for Fort Worth.

Jack Green sales manager

John G. Seiler, vice president and general sales manager of Tube Turns, Inc., Louisville, Kentucky, has announced the appointment of Jack Green as sales manager of the welding fittings division. A native of Louisville, he attended the University of Kentucky and was the American Radiator and Standard Sanitary Corporations' branch manager in Mans-

Jack Green

Tom Pike

field and Akron, Ohio, before his affiliation with Tube Turns in February, 1941. He was stationed in Chicago, as district manager, before becoming the division's assistant sales manager in June, 1943.

Succeeding Jack Green as assistant sales manager of the welding fittings division is Tom Pike. Born in Coalinga, California, he graduated from UCLA and is a specialist in refinery and oil well equipment. Determined to learn the petroleum industry literally from the ground up, his first job was as a "roughneck" in the Huntington Beach oil field. Then he became, successively, a warehouseman for Republic Supply Company of California and an engineer-salesman for W. R. Guiberson Company before taking over Tube Turns' Los Angeles office, in January, 1940. He subsequently became district manager in charge of the West Coast territory.

Mid-Continent manager

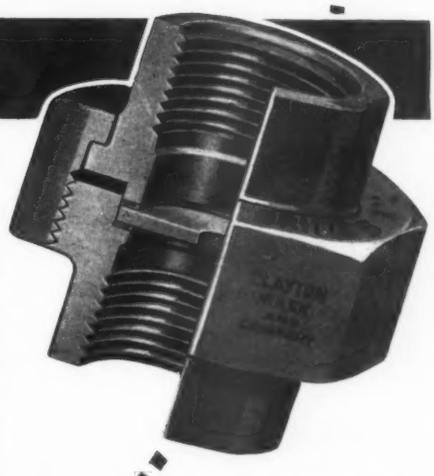
Jack H. Moyar, former division manager for Stanolind Oil and Gas Company in East Texas, West Texas, the Panhandle and New Mexico, has joined the staff of Security Engineering Company, Inc., as Mid-Continent manager and will have charge of all operations East of the Rocky Mountains.

J. H. Moyer

During the many years Jack was with Stanolind, he had charge of drilling and production of more than 800 wells in the Rocky Mountain district and several thousand in Texas and New Mexico. After leaving Stanolind he and D. S. White formed a partnership in a ranch in Montana, which will be continued under the direction of the latter.

ORIFICE
FORGED STEEL UNIONS

Orifice

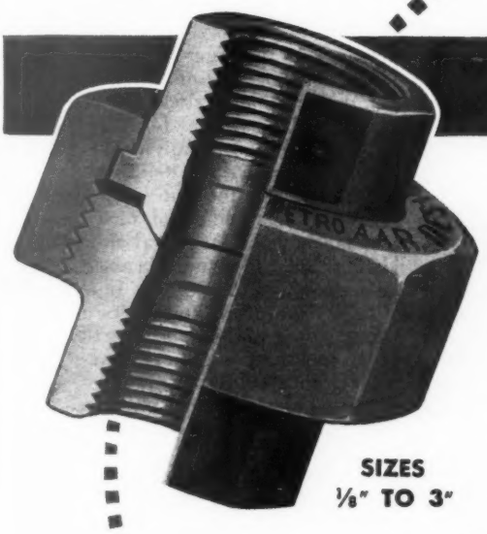


A SIMPLE, EASY-TO-HANDLE, MODERATELY PRICED, ORIFICE UNION.

Ideal for flow control of Steam, Oil, Ammonia, Water, Gas and Air. Also for metering and measuring. 600 lbs. S. W. P. or 2000 lbs. C. W. P. The ORIFICE plate is furnished in cold rolled 18-8 stainless steel. ORIFICE plate and gaskets are set in a groove of solid steel to safeguard against blowing of gaskets and resultant trouble. The ORIFICE union has extra heavy ends and nut with the nut threads permanently lubricated.

SIZES ¼" TO 3"

Petro



SIZES ⅛" TO 3"

AMERICA'S MOST UNIVERSALLY USED UNION

PETRO unions have integral steel to steel seats. Made to A. A. R. design. 600 lbs. S. W. P.-2000 lbs. C. W. P. Extra heavy ends and nut with nut threads that are permanently lubricated. The seats are machined and cold rolled.

A PARTIAL LIST OF PROVEN SERVICES

Pressures from a vacuum to 3000 lbs.: Temperatures from 100° below zero F. to 1000° above zero F.: On Steam, Gas, Air, Oil, Gasoline, Ammonia, Chemicals, and any service in which Steel or Wrought Iron Pipe is Used.

ORIGINATORS AND PIONEERS OF FORGED STEEL UNIONS SINCE 1912

WRITE FOR PAMPHLET AM-67 • ORDER BY TRADE NAME FROM YOUR JOBBER

CLAYTON MARK & COMPANY
1900 DEMPSTER STREET • EVANSTON, ILLINOIS

"Best Bet Yet"

These oil-proof, wear-resistant, plastic tubing protectors are an integral part of the tubing collar. Made in all sizes, they prevent the metal-to-metal contact that has caused many expensive "wet" jobs in pumping wells in the past.

PATTERSON-BALLAGH TUBING PROTECTORS

LOS ANGELES 1 • HOUSTON 10 • NEW YORK 6

Proved BY THE TEST OF TIME

RECTORSEAL has all the improvements which seven years of use by the Oil Industry has proved essential for a positive leak-preventer on threaded, gasketed, and coupled connections in lines handling all petroleum products, salt water, dilute acids, and steam up to 400 deg. F. It seals quickly, holds indefinitely, and will not freeze.

If you haven't tried RECTORSEAL recently, get a can from your supply store today.

Rector Well Equipment Co., Inc.
Fort Worth, Texas

Export:
LUCEY EXPORT CORP.
Woolworth Bldg.
N. Y. C.

RECTORSEAL
THE POSITIVE LEAK PREVENTER

To Sterling board

Addison F. Vars, president of the Sterling Engine Company, Buffalo, New York, announces that at the annual meeting Robert E. Dillon was elected to the board of directors.

R. E. Dillon

In addition to his directorship in the Sterling Engine Company, Dillon is also president and general manager of the Lake Erie Enginering Corporation, director of the Marine Trust Company, Air Investors, Inc., of New York City, and several other financial and manufacturing companies.

Officers of the Sterling Engine Company are: Spencer H. Logan, chairman of the board; Charles A. Criqui, vice chairman of the board and director; Addison F. Vars, president, general manager, treasurer and director; Hans Bohuslav, vice president-in-charge-of engineering and director, and Frank G, Raichle, secretary and director.

L. A. Nomads elect

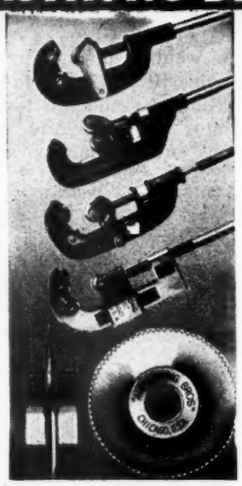
The January meeting of the Los Angeles Nomads, held as usual at the Mayfair Hotel, was a closed affair for the exclusive purpose of transacting the business of the organization and particularly the business of tallying the votes in the election of 1946 officers. These, incidentally, will be formally installed at the Inaugural Ball in the Biltmore Hotel, February 16, 1946. According to Elmer Smith, the out-going president, there is every indication of a record attendance at the inaugural and plans are being made to handle in excess of 400 members and guests. The function does honor to the retiring officers as well as those newly elected and is without question the most significant event in the Nomadic schedule.

It has been announced that the following have been elected to office for 1946: Wilbur F. Bettis, president; J. V. Robinson, vice president; Earl M. Daniels, secretary; William McGraw, treasurer; Wallace A. Sawdon, sergeant-at-arms; B. M. Landis, assistant secretary; Tom Martin, assistant treasurer; Dan Duncan, deputy sergeant-at-arms; regents—Roland Smith and Ted Sutter.

Acquires Hinderliter Tool

H. K. Porter Company, Inc., has acquired the Hinderliter Tool Company of Tulsa, Oklahoma, according to an announcement made by T. M. Evans, president of the Porter company. The Hinderliter Tool Company will operate as a division of H. K. Porter Company, Inc., and continue under the direction of F. J. Hinderliter, founder and president.

Look for the Arm-and-Hammer
ARMSTRONG BROS.



ARMSTRONG BROS. Pipe Cutters are made in all standard types. Each is a quality tool with hardened steel pins and rollers. "Saunders Type"—hardened end of thrust rod bears on inserted hard steel block (double life). In "Drop Forged" and "Combination" types, which take either 1 or 3 wheels, a replaceable hardened steel nut takes up thrust. In the "Barnes" type thrust rod threads through drop forged steel section.
ARMSTRONG BROS. Knife Blade Cutter Wheels (smooth or knurled) have thin penetrating edges that hold their keenness because they are machined from special vanadium tool steel, hardened and oil tempered. Fit all standard-make pipe cutters. . . . *Write for Catalog.*

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
331 N. FRANCISCO AVE. • CHICAGO, U.S.A.
Eastern Warehouse & Sales: 199 Lafayette St., New York, N.Y.

PUMPS for PETROLEUM PRODUCTS

Write for Bulletin 102— Pumps for the Petroleum Industry

It will tell you why
BLACKMER ROTARIES
are SELF-ADJUSTING FOR WEAR

GATHERING PUMPS
REFINERY PUMPS
BULK STATION AND TRUCK PUMPS
HAND PUMPS
SUCTION LINE STRAINERS

Capacities to 750 GPM.
Pressures to 500 psi.

BLACKMER PUMP COMPANY
1980 Century Ave., Grand Rapids 9, Mich.

SERVING THE PETROLEUM INDUSTRY FOR 40 YEARS

Norris sales manager

The appointment of G. W. (Bill) Davidson to the position of sales manager of W. C. Norris, Manufacturer, Inc., Tulsa, Oklahoma, is announced by J. H. Eustice, president.

G. W. (Bill) Davidson

Davidson has been with the Norris organization 10 years, starting in the plant at Tulsa and working in the machine shop, forge shop, warehouse, and then in the sales department. He has served as sales representative in the East Texas, Illinois, and Wichita Falls territories. He returned to Tulsa in 1944 and has been in charge of city sales up to the time of his appointment as sales manager.

Joins Patterson-Ballagh

Patterson-Ballagh Corporation recently announced the associaton of Earl Rees with that firm.

Rees has spent most of his working life in the oil tool business, where he has had a varied experience. His past associations have been with Republic Supply Company of California, Fluid Packed Pump Company, and Oil Well Manufacturing Company, occupying various positions from salesman to export manager and sales manager. The last 4 years have been spent with the United States Marine Corps, during which time he served as a captain.

Earl will represent Patterson-Ballagh throughout the State of California, spending a great deal of his time on the company's production items, which includes a new swab recently introduced to the trade.

He will make his headquarters at Patterson-Ballagh's office and factory in Los Angeles, California.

Expands facilities

The Shafer Bearing Corporation of Chicago, Illinois, has acquired an additional plant in Downers Grove, about 20 miles southwest of Chicago. As in the Belvidere factory, complete manufacturing operations will be carried on in this ultra-modern building, which was erected only 4 years ago. New machine tools, equipment for electric induction heating used in hardening processes, and other important developments in manufacturing techniques of the last 4 years are being installed. It is expected that production will begin in March of this year.

The new building is situated on 5½ acres of land, affording ample opportunity for further expansion contemplated later in the year.

General office and administraiton activities will continue at the present Shafer Bearing Corporation building at 1412 West Washington Street, Chicago.

Pumping Without Pampering

Huntington Beach, California, where this Case "DE" Oilfield Engine was photographed, is just like any oil area in one respect. The big thing is to keep oil coming up, keep man-hours down. A big aid to both these aims is the ENDURANCE built into Case engines.

Their compact convenience shortens routine attendance. Quality construction in every part minimizes the risk of shutdown, reduces minor maintenance. Extra months of running before major overhaul holds performance high, holds overall costs low. Good governing and unfaltering power even at half-speed afford flexibility in rate of pumping.

Case Oilfield Engines are built in 28, 40, and 57 H.P. sizes, and fitted for gas or liquid fuels. For full information call the distributor who maintains service in your area. J. I. Case Co., Racine, Wis.

DISTRIBUTORS

Southwest Machinery Company
1900 Linwood Blvd., Oklahoma City; Tulsa and Hobart, Oklahoma

Wm. K. Holt Machinery Company
San Antonio, Texas

Southwest Equipment Company
Dallas and Kilgore, Texas

Gulf Tractor and Equipment Co.
3100 Polk Street, Houston, Texas

OIL FIELD ENGINES

CASE

Water-flooding conference for Mid-Continent area held at Chanute, Kansas

About 60 oil men, including engineers, attended the first of a series of periodic conferences for the discussion of water-flooding operations and problems in the Mid-Continent area. Marion Stekoll, an operator from Independence, Kansas, presided at this first meeting, which was held on January 24 at Chanute, Kansas. Many operators of water-flood projects in the East Kansas and Northeast Oklahoma areas were present or represented. W. L. Horner of Barnsdall Oil Company, Tulsa; R. C. Earlougher of Earlougher Engineering, Tulsa; H. C. Fowler and D. B. Taliaferro of the U. S. Bureau of Mines, Bartlesville; W. A. Heath of Phillips Petroleum Company, Bartlesville, and Paul Hedrick of the *Tulsa World* were among those present.

All who are interested in such water-flooding subjects as channeling, selective plugging and shooting, and methods of lowering the produced water-oil ratio are invited to attend the next conference, which is to be held at 7:30 o'clock, February 27, in the Booth Hotel at Independence, Kansas. Inquiries may be directed to Stekoll or Taliaferro.

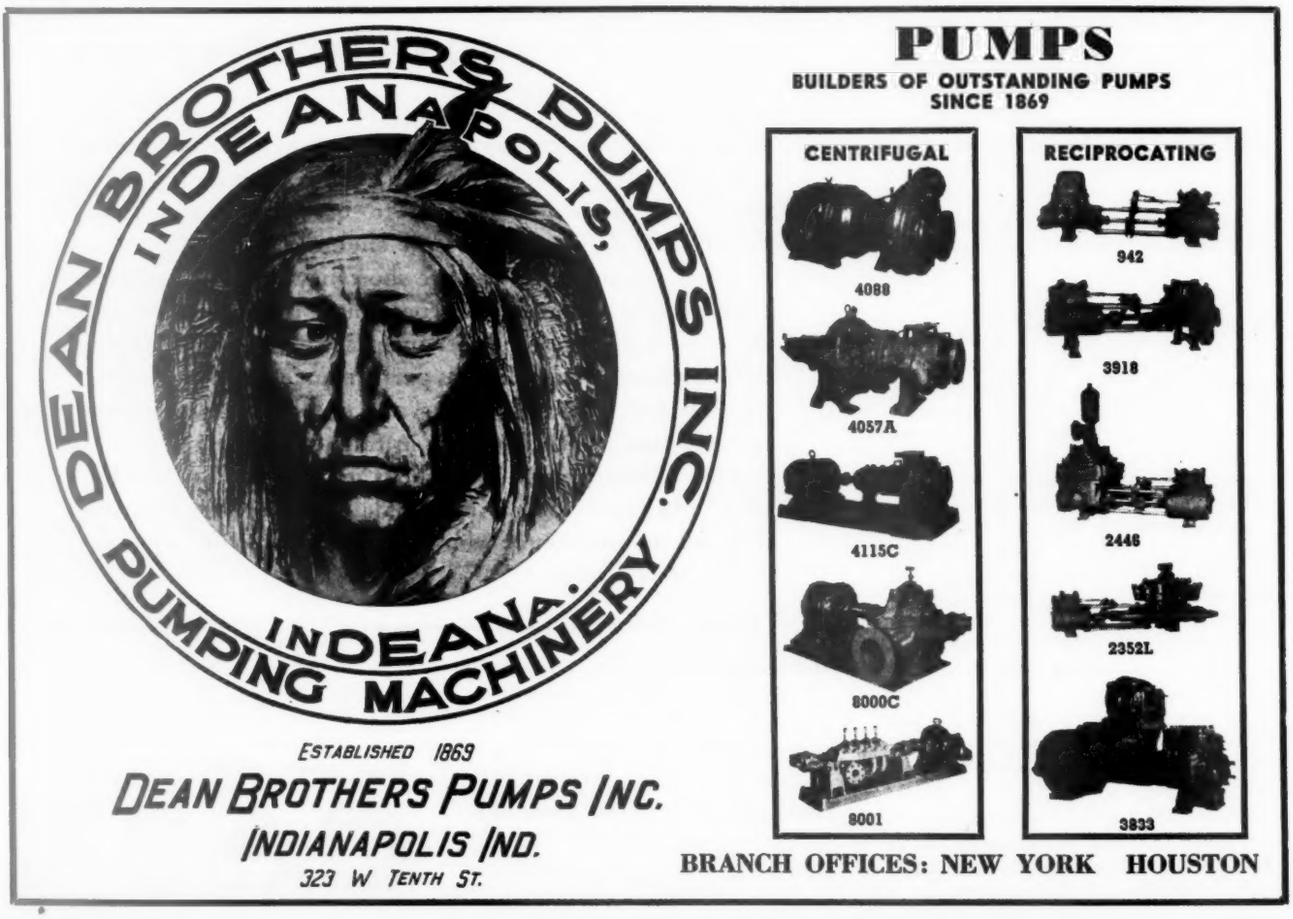
Oklahoma distributor

Globe Oil Tools Company of Los Nietos, California, announces the appointment of Manufacturers Warehouse Company, 1531 West Main Street, Oklahoma City, Oklahoma, as distributor for the complete line of Globe oil tools. Orville L. Wildman, general manager for Manufacturers Warehouse Company, has recently returned from Europe where he served in the Armed Forces.

Opens technical section

The International Nickel Company, Inc., announces the opening of the Twin Cities Technical Section of its Development and Research Division as of January 15. It is in the Northwestern Bank Building, 620 Marquette Avenue, Minneapolis, Minnesota.

The new section, under direction of J. C. Neemes, Jr., metallurgist, will supply technical assistance to industry in territory embraced by the states of Minnesota, North and South Dakota, the northern two-thirds of Wisconsin, and the northern part of Michigan.



Eustice heads Norris company

At a special board of directors meeting of W. C. Norris Manufacturer, Inc., Tulsa, Oklahoma, J. H. Eustice was elected president to succeed the late Don S. Bowers.

Eustice has literally grown up with the company he now heads. He began working for W. C. Norris 35 years ago, when he was 11 years old. That was in 1911, just a few months after the plant was moved to Tulsa from Tiona, Pennsylvania. His father being one of the men whom Norris brought with him in the move.

J. H. Eustice

He worked mornings, evenings, Saturdays, holidays, and vacations at miscellaneous odd jobs until he finished school, when he became a full time employe and was put in charge of the warehouse and shipping departments. A year later he was transferred to the office by Don Bowers as bookkeeper, and in 1925 he was relieved of the bookkeeping job and began sales work. In 1936 he rose to the position of sales manager. In 1943 he became general manager, and in 1945 with the death of Norris and the election of Don Bowers to president of the company, Eustice was made executive vice president.

Farmer partner in drilling firm

John O. Farmer, for 11 years field engineer and general sales manager for Otis Pressure Control, Inc., Dallas, Texas, resigned this connection January 1 to become a partner and general manager in the newly created drilling company of Jones, Shelburne and Farmer, Inc.

John Farmer

Officers of the new drilling firm are Fred Jones, president; John O. Farmer, vice president, and Sam P. Shelburne, secretary-treasurer. This firm plans to put into operation a number of rigs in the immediate future. General headquarters will be maintained in Oklahoma City, Oklahoma.

MacClatchie opens Casper office

In an expansion program to facilitate sales and complete service in the Rocky Mountain area, MacClatchie Manufacturing Company, Compton, California, announces the opening of a new sales office and warehouse at 133 North Wolcott Street, Casper, Wyoming.

Cliff Ford is in charge of the company's new office as factory representative. Cliff has long been associated with the oil equipment business, having for the last 2 years held a similar position with MacClatchie Manufacturing Company in the west Texas area.

C. I. SIMS

Corrosion Engineering Service

Specializing in Cathodic Protection of Pipe Lines, Plant Installations, and Tank Farms.

Box 761 **Dallas, Texas**

. . . Provide Four Point Security

Here are FOUR TANGIBLE REASONS why Phoenix Flanges will give you the utmost in safety, service, and satisfaction:

1. They're drop forged so that grain flow of the metal is positioned to provide maximum strength and toughness in those portions of the forging where it is most needed.
2. They're made of mild steel especially adaptable to welding and machining, and are available in a wide range of styles and sizes. Phoenix Flanges made of stainless steel, Everdur brass, and other alloys are also obtainable, on special order.
3. They're both Normalized and Annealed for long wear and strength, in precision-controlled heat treating furnaces.
4. They're lacquer finished to resist rust and corrosion.

Every Phoenix Flange complies with ASA requirements and ASME and ASTM specifications.

For safety, service, and satisfaction specify Phoenix Flanges. Write for your free copy of the new Phoenix Flange Catalog today.

Flange Division of

PHOENIX MANUFACTURING COMPANY

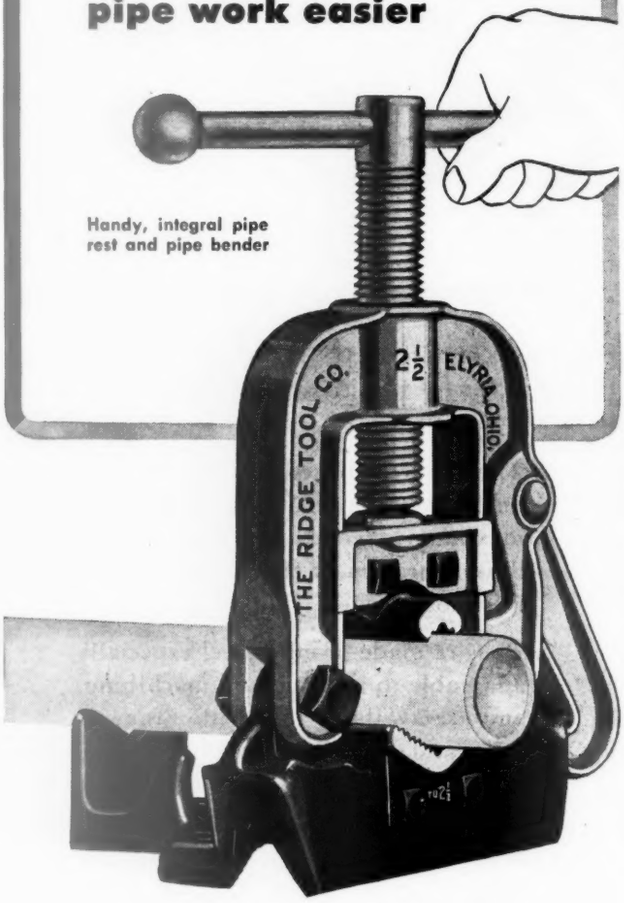
CATASAUQUA, PA. JOLIET, ILL.

This handy Red-Top

RIDGID

yoke vise makes your

pipe work easier



● Look for the red yoke on a black base when you buy a bench vise—for this sturdy RIDGID of strong special malleable offers you unusual convenience. It has an integral pipe rest for easier cutting and threading; it has a handy pipe bender. Its tool-steel LonGrip jaws are easy on polished pipe. It's more for your money—buy in any of 8 sizes for pipe to 6 inches, at your Supply House.

RIDGID *Vises, Yoke & Chain in 9 styles, 23 sizes.*

RIDGID

WORK-SAVER PIPE TOOLS

THE RIDGE TOOL COMPANY · ELYRIA, OHIO, U. S. A.

Returns to Reed Roller Bit

The Reed Roller Bit Company, Houston, Texas, announces the return of John Teer to its organization as special representative.

John Teer

After many years in production work for the Reed organization, Teer took over the management of the Layne and Bowler Company of Houston. As president and general manager of this company, he established himself as one of the most well liked and efficient executives in the oil industry.

Shortly after Pearl Harbor, he was contacted by government representatives and asked if he would undertake the construction and management of the Dickson Gun Plant in Houston. Teer gladly accepted this responsibility and, due to his excellent management, the plant was cited by the government as one of the most successful arsenals in the country for low cost of production and for efficiency of operation.

Teer will make his headquarters in Houston.

Heads Dearborn's marine division

After 4 years of active duty in the Navy, Lt. Comdr. Charles S. Silsbee, formerly of Dearborn Chemical Company's marine division, has been released from service and again joins the Dearborn staff as the new head of the marine division.

C. S. Silsbee

His headquarters will be in the New York offices of the company.

Silsbee was graduated from the United States Naval Academy in 1925 and served 2 years aboard the Battleship Idaho.

In World War II, his navy assignment was that of planning officer. With a staff of marine engineers and naval architects, he supervised all planning in the conversion and construction of commercial-type vessels for naval service in the Baltimore area.

The knowledge thus gained will be of immeasurable value in the application of Dearborn products and services in the marine field.

A look into human side of oil

C. K. Stillwagon, owner and general manager of Well Equipment Manufacturing Corporation, Houston, has recently had published a human interest book on oil, titled "Rope Chokers," 228 pages of story telling taken from his personal experiences in the industry during the past 30 years.

C. K. Stillwagon

Besides giving the reader an intimate look into the ramifications of the industry as it grew from a struggling pioneer's game to one of the world's richest and most vital industries, "Rope Chokers" puts on record many valuable statistics. More than 60 pictures, chiefly oldtimers, add much interest to the personal touches of oil field life portrayed by the author.

Disclaiming any ability as a writer, Stillwagon explains his book as an interesting form of relaxation, in spare time, to get off his chest a story he had to tell. But readers who know the oil industry can readily see in "Rope Chokers" that he knows and has lived his subject.

Named sales manager

Orville F. Figley of Wilmette, Illinois, since 1942 assistant manager of sales, Chicago district of United States Steel Supply Company, has been appointed sales manager succeeding Andrew Verschuur who retired December 31 after more than 51 years service with this U. S. Steel Corporation subsidiary.

International shows new plant

Four hundred industrial equipment distributors, manufacturers, and editors attended an informal opening of the Melrose Park Works and preview of new industrial power products held by International Harvester on January 29, during the 27th annual meeting of the Associated Equipment Distributors in Chicago. The group was taken on a tour of the immense new International plant, which is situated on a 125-acre tract west of Chicago and has more than 2,000,000 sq. ft. of roofed floor space. During the inspection of the plant, future operations were explained by representatives from the company's manufacturing department. The tour ended with a display of International's present and future Industrial power line at the administration building.

The TD-24, International's streamlined new diesel crawler tractor, was the center of interest at the display. This big new

Aerial view of Melrose Park Works.

crawler tractor, weighing approximately 35,000 lb. and with 130 drawbar hp., will be the largest ever built by International Harvester. Other new products, for production at a later date, were a marine diesel engine, several new power units, and a large industrial wheel tractor. Earlier production is planned for two of the power units, the UD-14A and UD-18A, 76 and 125 max. hp., respectively.

Company engineering and sales representatives were on hand to answer questions about the new power units and tractors as well as the current line, which made up the rest of the exhibit. The service exhibit and approximately 100 enlarged photographs of International tractors and International-powered allied equipment also drew considerable attention.

National Tube appointments

Appointment of O. P. Adams as director of development, National Tube Company, Pittsburgh, Pennsylvania, is announced by E. H. Sanders, vice president in charge of operations of this United States Steel subsidiary. Adams has been assistant general superintendent of the company's National Works, McKeesport, Pennsylvania, since September, 1942.

Also announced is the appointment of T. H. Kennedy as assistant general superintendent at National Works and the retirement of J. Jay Dunn as assistant to vice president—operations.

Acquires Arcade Manufacturing Co.

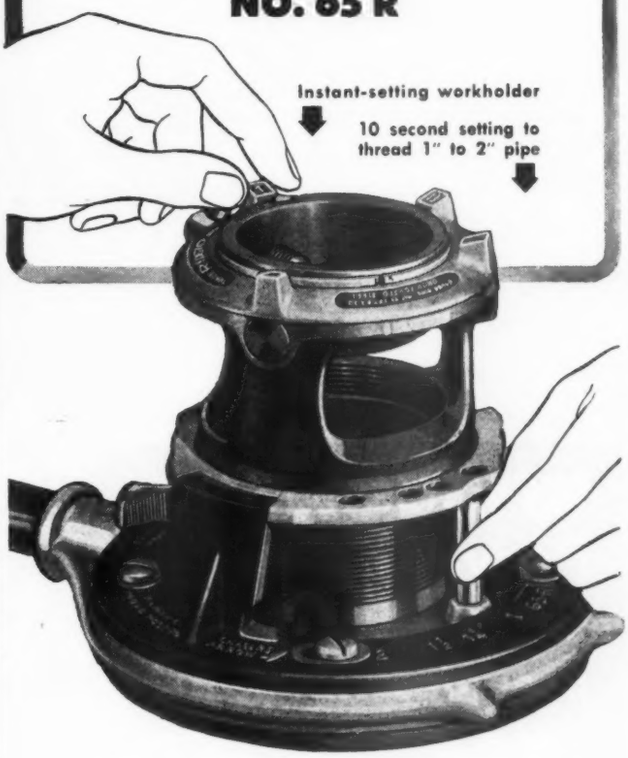
Acquisition of the Arcade Manufacturing Company, Freeport, Illinois, by the Rockwell Manufacturing Company of Pittsburgh is announced by Colonel Willard F. Rockwell, president and chairman of the Rockwell company.

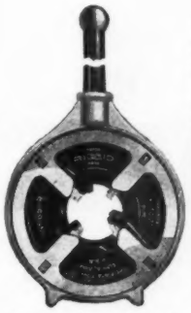
Present management of the Arcade company will be continued, except that L. L. Munn, for many years president, will retire within the near future.

You enjoy smoother, easier pipe threading with this self-contained semi-automatic . . . . .

RIDGID

NO. 65 R





It stands up handily on the floor.

● Precision-made and tested in every one of its 23 rugged steel-and-malleable parts, the 65R gives you fast, smooth, almost effortless pipe threading. Clean perfect 1", 1¼", 1½" and 2" threads with one set of high speed steel dies that adjust to size in 10 seconds. Workholder sets to pipe size instantly —1 screw and no bothersome bushings. You enjoy owning and using this modern threader —. order from your Supply House.

RIDGID

WORK-SAVER PIPE TOOLS

THE RIDGE TOOL COMPANY • ELYRIA, OHIO, U. S. A.

Rejoins Dollinger Corporation

After 5 years' military service, including more than 2 years overseas duty as officer of an anti-aircraft battalion in the European Theater, Lewis L. Dollinger, Jr., has received his discharge and is again associated with the Dollinger Corporation.

L. L. Dollinger, Jr.

In addition to duties connected with his recent election as vice president of the company, Dollinger will act in a sales engineering capacity. He is a mechanical engineer, Cornell University class of 1938, and spent 2½ years in the engineering and sales department of Dollinger Corporation before entering military service with the 209th Coast Artillery Regiment.

Sexton to Bradford Motor

Ray M. Sexton has resigned as sales manager of W. C. Norris, Manufacturer, Inc., to accept the same position with Bradford Motor Works, Inc., of Bradford, Pennsylvania. The Bradford Motor Works are manufacturers of a line of oil well pumps and other production specialties and maintain complete factory stocks at the Mid-Continent branch at Tulsa, Oklahoma.

R. M. Sexton

Sexton will continue to reside in Tulsa and make his headquarters at the company's branch there.

Welding staff increased

In line with its program for expanding the staff of field welding engineers to serve all users of welding, The Lincoln Electric Company, Cleveland, Ohio, announces the addition of the following district office representatives:

Omer W. Blodgett has been appointed welding engineer for the Grand Rapids, Michigan, area. During the last 4 years he was welding superintendent for the Globe Shipbuilding Company, Superior, Wisconsin.

Frank Boucher has been appointed welding engineer in the Detroit, Michigan, area. Boucher worked in Lincoln Electric's service and sales departments for nearly 6 years prior to his recent appointment.

R. K. Kewley has been appointed welding engineer in the Cleveland territory. Kewley was formerly a member of Lincoln's engineering department at the company's home office. His recent assignment follows a period of active service with the United States Army.

G. B. Moseley has been appointed welding engineer in the St. Louis, Missouri, area. His latest business connection before joining Lincoln Electric was with Jack & Heintz, Inc.

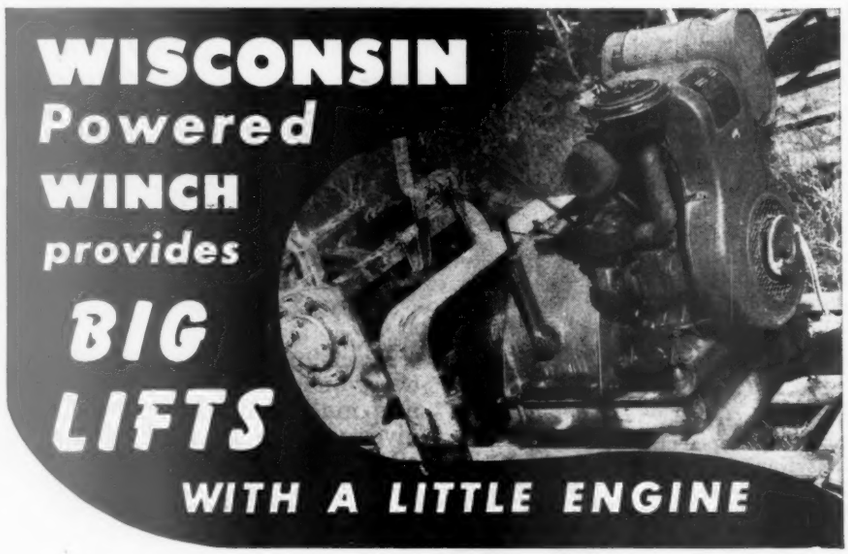
Captain L. J. Cogan, recently released from the United States Army, has returned to his duties as welding engineer in the Philadelphia area.

Petroleum and chemical division

J. A. Jones Construction Company, Inc., Charlotte, North Carolina, announces the opening of a petroleum and chemical division with headquarters in the Scanlan Building, Houston, Texas. In charge of the new division are J. J. Allison, vice president, and Gordon T. Granger, manager.

Allison recently was chief resident engineer of the atomic bomb project at Oak Ridge, Tennessee, and prior to that was vice president of Lion Oil Refining Company, El Dorado, Arkansas. Granger recently was district director of refining for the Petroleum Administration for War at Houston and before that was refinery manager for Bareco Oil Company at Corpus Christi, Texas.

J. A. Jones Construction Company has been active in construction engineering in nationwide general industrial work since 1894.



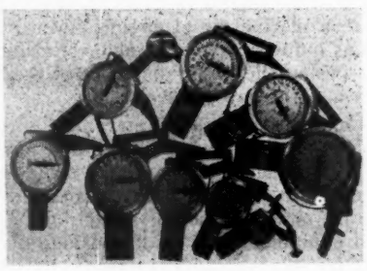
This rugged field service unit, comprising a winch powered by a Model AHH 9 hp. 4-cycle, single cylinder Wisconsin Air-Cooled Engine, fitted with Greenfield clutch reduction assembly, is used in raising heavy telephone poles, lifting logs, etc., in southern Oklahoma. Adapted to a great variety of hoisting jobs . . . such as handling pipe, loading and unloading equipment and any other heavy lifting requiring heavy-duty power. Supplied by Harley Sales Co., Tulsa, Oklahoma.

Wisconsin Air-Cooled Engines are first choice among operators who place a premium on ready-to-go, hard slugging dependability and all-weather serviceability.

WISCONSIN MOTOR Corporation
MILWAUKEE 14, WISCONSIN
World's Largest Builders of Heavy Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
510 Atlas Building, Tulsa, Oklahoma
M & M Building, Houston, Texas
Oil field distributors for Wisconsin Engines and all types of utility units.

LINE SCALES



10 of the 20 Models we manufacture. 40,000 pounds to 500,000 pounds. A special scale for any job.

With a Line Scale you know the pull on the line, and the weight on the bit in pounds. Accurate, sensitive, rugged and economical.

Line Scales are dependable, even in areas of rapid temperature changes. Repeated tests prove the accuracy of Line Scale readings under all working conditions.

See your supply man, now.

LINE SCALE CO., INC.
Phone 2-1765, 907-11 SE. 29th Street, Box 4245
OKLAHOMA CITY, OKLAHOMA

F. M. Porter heads association

At the twenty-eighth annual meeting of the board of directors of the Mid-Continent Oil and Gas Association, held in Tulsa, Oklahoma, January 22, F. M. Porter, Fain-Porter Drilling Company, Oklahoma City, was elected president to succeed the late J. C. Hunter of Abilene, Texas, who passed away on November 11, 1945. Porter becomes the sixth president of the Mid-Continent Oil and Gas Association.

F. M. Porter

Jake L. Hamon, Cox and Hamon, Dallas, Texas, was elected as first vice president of the association replacing Porter, who held that office during the year 1945.

H. E. Zoller, The Derby Oil Company, Wichita, Kansas, was elected vice president for Kansas, succeeding E. B. Shawver of Wichita, who refused reelection.

A. H. Weyland, Arkansas-Louisiana Gas Company, Shreveport, Louisiana, was elected as vice president for Louisiana-Arkansas, succeeding D. W. Harris who has removed his residence from Shreveport to Chicago.

All other officers were reelected, as follows: Vice president for Oklahoma, E. F. Bullard, Stanolind Oil and Gas Company, Tulsa; vice president for Texas, George C. Gibbons, Texas division, Mid-Continent Oil and Gas Association, Dallas; vice president for Mississippi-Alabama, C. L. Morgan, Dixie Geological Service, Jackson, Mississippi; vice president for New Mexico, Van S. Welch, Flynn, Welch and Yates, Artesia, New Mexico, and general secretary-treasurer, Clarel B. Mapes, Tulsa.

At the annual meeting of the board of directors, the affairs and activities of the Mid-Continent Oil and Gas Association during the year 1945 were reviewed and the program and policies of the association for the ensuing year were determined.

Among other actions, the directors adopted a memorial resolution dedicated to Judge Hunter.

Instrument society formed

In the area surrounding Corpus Christi, Texas, the men working with and interested in all types of control and measuring instruments have formed the South Texas Instrument Society. Plans are made to affiliate with the Instrument Society of America, a new national society of control and measurement engineers in the near future.

Meetings are held the second Tuesday of each month, the meeting place decided on at the preceding month's meeting or shortly after this meeting.

At the January meeting, members from the U. S. Naval Air Station at Corpus Christi, Texas, gave interesting talks on automatic airplane pilots, gun sights, and navigation. At the January meeting, Mr. Allegret of the Schlumberger Well Surveying Corporation gave an illustrated lecture on electric well logging.

All men having any contact with controlling and measurement equipment of any type are invited to attend meetings and become members.

Information may be obtained from the president, J. G. Pratt, 526 Villa Drive, Corpus Christi, Texas.

Marsteller advertising head

Wm. A. Marsteller has been appointed general advertising manager of Rockwell Manufacturing Company, Pittsburgh, Pennsylvania, it is announced by A. J. Kerr, vice president of sales of the Rockwell organization.

Marsteller has been vice president in charge of sales, advertising and industrial relations of Edward Valves, Inc., East Chicago, Indiana, a subsidiary of the Rockwell Manufacturing Company.

He is president of the Chicago Industrial Advertisers Association and a director of the National Industrial Advertisers Association and the Chicago Federated Advertising Club.

Subsidiaries and divisions of the Rockwell Manufacturing Company will continue to program and place their own advertising. Marsteller's work will be of a coordinating and directing nature.

AIRETOOL'S NEW FORM CUTTERS

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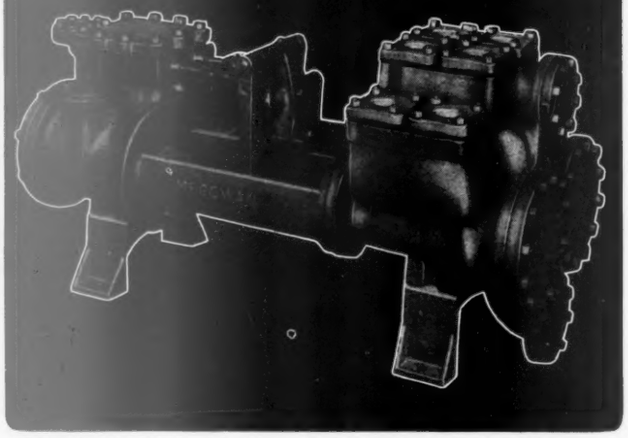

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NGAA convention committee announced

P. M. Raigorodsky, vice president, Glen Rose Gasoline Company, Houston, Texas, is to head the convention program committee for the 25th annual convention of the Natural Gasoline Association of America, according to an announcement by the president of the association, J. H. Dunn, president, Shamrock Oil and Gas Company, Amarillo. The convention is scheduled for April 17-19 at the Baker Hotel, Dallas.

Other members of the committee appointed by Dunn are: John B. Atkins, The Parade Company, Shreveport; H. W. Manley, Barnsdall Oil Corporation, Tulsa; Frank Matheny, Phillips Petroleum Company, Bartlesville; I. Earl Nutter, Hagy, Harrington and Marsh, Amarillo; Robert T. Wilson, La Gloria Corporation, Corpus Christi, and W. E. Winn, Sun Oil Company, Dallas.

In commenting on plans for the 3-day meeting, Dunn stated elaborate preparations were being made for the first open discussions of radically changing conditions within the industry in several years.

"The NGAA is to celebrate its 25th anniversary at a time when the industry is passing from its traditional 'one product' phase into one of broadly expanded operations in which it will probably meet demands for many products," he said. "Both the natural gasoline and cycling industries are in enviable positions today with respect to motor fuel and chemical raw material markets. Their modern plants have an efficiency of fractionation permitting the maximum extraction of valuable hydrocarbons either as pure products or in many desired blended combinations. This war stimulated modernization, the introduction of new processes and the potentialities of the changed operations need to be studied and correlated, and that is to be the theme of this first convention in two years."

Urges price control exemption

Equipment distributors were urged to ask their congressmen to pass legislation exempting capital goods from price control as F. N. Bard, owner of the Barco Manufacturing Company, addressed a group of Barco distributors at the Edgewater Beach hotel, Chicago, during the convention of the Associated Equipment Distributors.

Bard said the purchasers of capital goods have purchasing agents, statistics, and facts upon which to make their purchases and they have to make a profit on their operations. Therefore, they are able to take care of themselves and do not need any control.

"If legislation were passed exempting capital goods from price control, consumer goods could get moving faster," he said.

R. J. Eiche expands facilities

Announcement has been made recently by R. J. (Bob) Eiche, veteran export representative, of the opening of New York offices at 30 Church Street, under the management of H. E. (Herb) Maland. Maland is a well known charter member of the New York Chapter of Nomads, and for the last 7 years has been connected with the Chiksan Company as New York sales manager. In addition to export representation, the New York sales office will also represent and direct the sales and service for the Hamer Oil Tool Company for its eastern states division.

Eiche will divide his time between New York and Los Angeles where export offices are maintained in the Petroleum Building, 714 West Olympic Boulevard. T. G. (Tom) Martin, a veteran Nomad and an associate of Eiche's for many years, will leave soon for an extended tour of the oil fields in South America.

Named Chicago manager

Clarence L. Johnson, a member of the sales staff at the Dugas office at Chicago for Ansul Chemical Company, Marinette, Wisconsin, was appointed manager of that office effective January 1. He succeeds Floyd M. Duvall who has been transferred to Indianapolis where he will be district manager of refrigeration sales.

Book Reviews

● **Additive Engine Oils.** *Compiled, edited and published by the Petroleum Educational Institute, 704 South Spring Street, Los Angeles 14, California. Price, $3.75.*

"Additive Engine Oils" is a short and simple explanation of detergent oils and detergent purging fluids for the benefit of maintenance personnel at service stations, car and truck dealers, repair shops, and fleet operators. Simplicity was the keynote of the editorial staff of the Petroleum Educational Institute in compiling the text and illustrations of this highly informative book.

This work is an effort to contribute further to the elementary material already published on the subject of petroleum and its products, and also to collect and make available, in one book, many scattered contributions of great value.

● **Procedure Handbook of Arc Welding Design and Practice.** *Published by The Lincoln Electric Company, Cleveland 1, Ohio. Price $1.50. Pages, 1282.*

This eighth edition of Procedure Handbook is planned to include improvements in the electric arc welding processes that have occurred in the last few years. It presents in convenient form for ready reference the basic information on arc welding and includes a complete description of the process. A large portion of the book is devoted to designing for arc welding construction of machinery and structures. Another section is devoted to typical applications of arc welding in manufacturing, construction and maintenance. The book is profusely illustrated.

● **Advancing Fronts in Chemistry, Volume I, High Polymers.** *Edited by Sumner B. Twiss. The Reinhold Publishing Corporation, 330 West Forty-second Street, New York. Pages, 196. Price, $4.00.*

This volume contains the series of lectures on the subject of high polymers delivered during the Spring of 1944 at Wayne University under the direction of Dr. Neil E. Gordon. The lectures and the book are an attempt to correlate recent and diverse information on the subject. The book gives a logical development of the recent history of high polymers and is prepared for beginners as well as trained investigators in the field. The book is divided into 10 chapters covering the 10 lectures in the series. The chapters are: Molecular Structure and Mechanical Behavior of High Polymers by Herman F. Mark; The Relation Between Structure and Physical Properties of High Polymers by Samuel S. Kistler; Some Applications of Catalysis to Hydrocarbon Reactions of Importance in the Synthesis of High Polymers by Edgar C. Pitzer; Some Aspects of the Mechanism of Addition Polymerization by Charles C. Price; Polymerization as a Study of Reactions of Free Radicals by Frank R. Mayo; Molecular Size Distribution in High Polymers by Walter H. Stockmayer; Effect of Chain Length on Physical Properties of Cellulose Derivatives by Emil Ott; Nature of the Solid State of Chain Polymers by William O. Baker; Mechanical Properties of Concentrated Solutions of High Polymers by John D. Ferry; and Some Concepts of Textile Fibers by Milton Harris.

● **Gas Measurement With Portable Equipment, Manual II of Metering and Handling of Natural Gas.** *Industrial and Business Extension Training Bureau, Division of Extension, University of Texas and State Department of Vocational Education, Trade and Industrial Division, Austin, Texas, Pages, 43.*

This is the third of a series of 4 pamphlets being prepared under the general title, Handling and Metering of Natural Gas. The series is designed for group instruction of nontechnical field personnel of the petroleum production industry. It is estimated that the material in this fourth manual may be covered in 12 to 20 class hours, depending on the background of the personnel. The booklets already published are: Manual I, Introduction to the Study of Natural Gas; and Manual II, Field Handling of Natural Gas. The fourth, to be released, will be Gas Measurement with the Orifice Meter.

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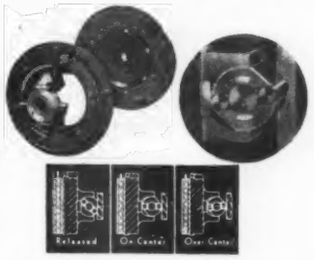

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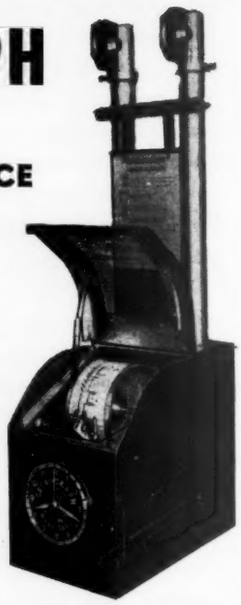

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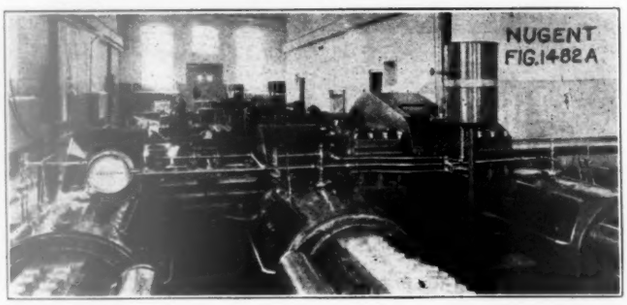

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Carter Oil men promoted

M. A. Wright

R. J. Sullivan

C. G. Herrington

Transfer of M. A. Wright, assistant manager of the production department of The Carter Oil Company, from Tulsa to New York to be the company's representative there, is announced by O. C. Schorp, president.

R. J. Sullivan, Mattoon, Illinois, superintendent of Carter's eastern division, has been named to Wright's post.

C. G. Herrington, chief production engineer, succeeds Sullivan as eastern division superintendent, and A. R. West, Billings, Montana, division engineer of Carter's northwest division, replaces Herrington. M. C. Sons, petroleum engineer in the Tulsa office, goes to Billings as northwest division engineer.

The changes are effective immediately.

Wright was graduated from Oklahoma A. and M. college in 1933. He went to work for Carter in the Seminole district, became division engineer in the central division in 1939, was division engineer of the southern division at Shreveport, Louisiana, in 1941 and in 1943, returned to the Tulsa office. He has served as petroleum engineer, chief engineer, and assistant manager of the production department.

Sullivan was graduated from Notre Dame university in 1931, took special work in petroleum engineering and geology at the University of Oklahoma, and began work for Carter in 1934 in the Burbank field as roustabout. After serving in the Burbank district, western Oklahoma and Kansas, and the Tulsa office, he went to Mattoon as division engineer in 1938, was made assistant division superintendent, and 2 years ago, became division superintendent.

Minkler addresses alumni association

At a meeting of the Cal Tech Alumni Association, held in the University Club, Los Angeles, January 17, the speaker of the evening was R. L. Minkler, vice president and director of General Petroleum Corporation and former director of petroleum supply for PAW, who chose as his subject, "Oil at War." Discussing first the role played by the American oil industry in the search for adequate reserves, Minkler pointed out that despite the tremendous withdrawal necessitated by the war, reserves at its close were more than they were at the beginning.

In the production of 100-octane aviation gasoline, great progress was made. Beginning with a total prewar output of some 30,000 bbl. a day, huge new refineries, incorporating the most

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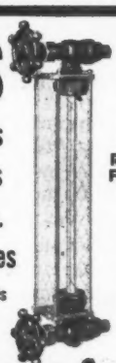

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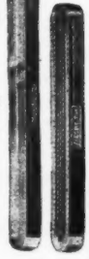

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modern facilities were built and put on stream in remarkably short time, with the result that in a short time, the national production of this vital wartime commodity was boosted to a daily total of 616,000 bbl. To this expeditious development the allied victory was due in large measure, he said.

It was in his handling of the transportation and logistical considerations that Minkler really waxed warm. The problem of transferring sufficient oil of the right type to the right place at the right time was fraught with many difficulties but it was taken care of with dispatch and with surprising completeness despite its immensity. Some conception of what was involved may be gathered from the following few statistics that were among those cited by the speaker:

1. Two-thirds of all tonnage carried overseas was petroleum or its derivatives.
2. The weight of liquid fuel and oil products shipped overseas was 16 times greater than that of the food.
3. The invasion of Okinawa required enough gasoline to keep 30,000 passenger cars running for a year.
4. One B-29 consumed enough gasoline during a one-hour flight to fuel a civilian automobile for 5½ years.
5. Thirty-one million 5-gal. cans of gasoline were delivered for the North Africa campaign.

By pooling, economizing, and coordinating oil transportation facilities, it was possible, out of 100,000 tank cars available to segregate and allocate 75,000 to this particular job. Deliveries were actually made to the east coast at the rate of a million barrels a day when it was vitally essential that an unrestricted flow of such dimensions be maintained, if operations in Europe and North Africa were to be successful. When it is remembered that there was a corresponding urgency for the simultaneous shipment of foods, clothing, armaments, and material, the achievement of the supply group is all the more commendable.

Tulsa Nomad officers

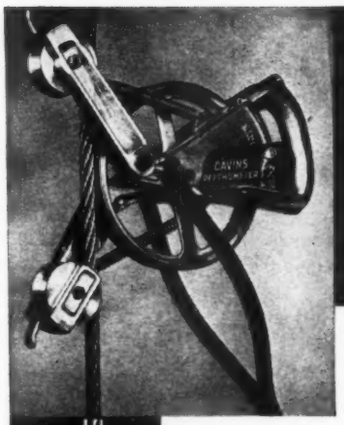
New officers of Tulsa chapter of Nomads were installed recently at the annual dinner. They were: Henry Bourne, president; Russell Hunt, vice president; Mitchell Tucker, secretary; Earle E. Smith, assistant secretary; M. D. Gilbert, treasurer; K. O. Hoevel, assistant treasurer; J. H. Eustice, sergeant-at-arms; Gene Elder, deputy sergeant-at-arms, with Shep Miers and W. G. Green as regents.

Principal speaker was Col. J. Carroll Cone, vice president of Pan American World Airways, New York, who discussed "International Air Transport Policy."

Dayton Rubber executive vice president

Bert R. Prall, former vice president and general manager of operations and member of the board of directors of Montgomery Ward and Company, Chicago, Illinois, became executive vice president of The Dayton Rubber Manufacturing Company on January 21, according to an announcement by A. L. Freedlander, president and general manager of the company. Prall was associated with Montgomery Ward for the last 26 years.

The office of chairman of the board will be left vacant, and those duties will continue to be combined with the office of Freedlander.



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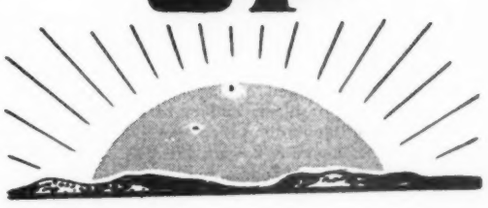

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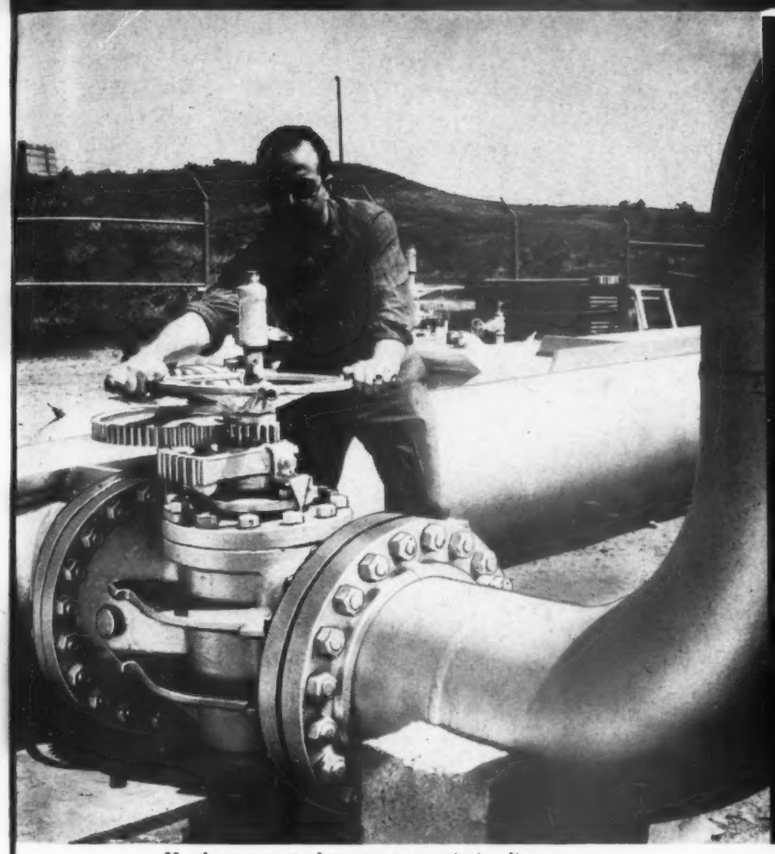

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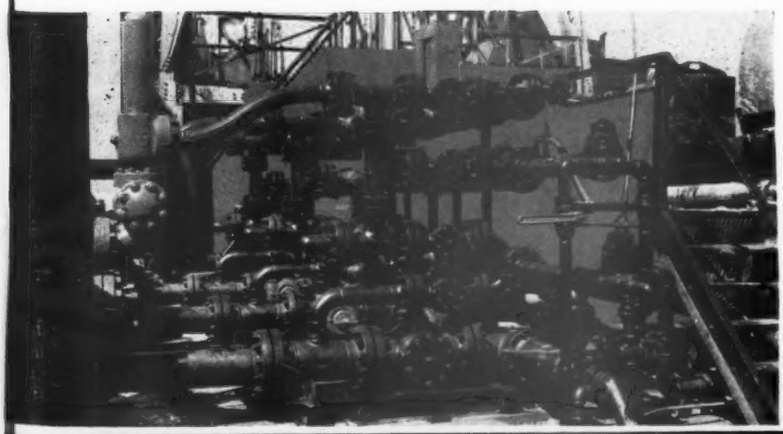

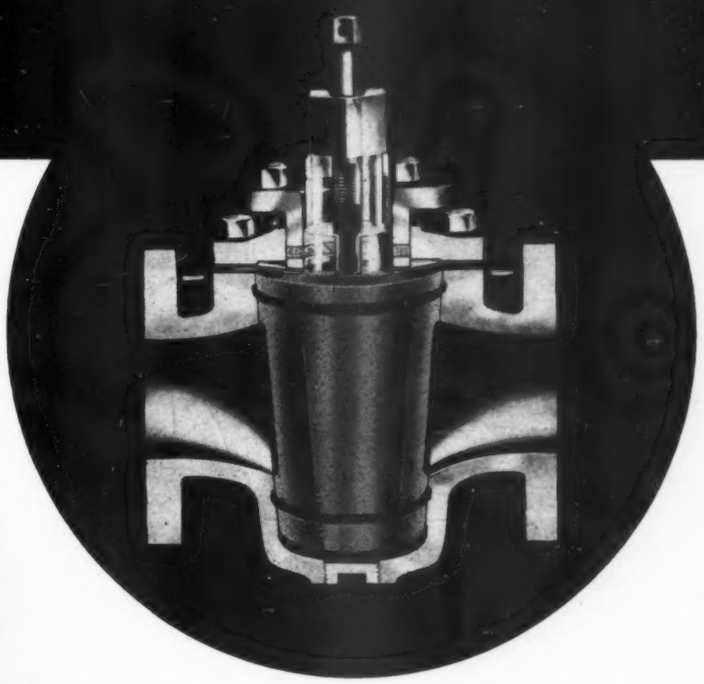

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MAIN OFFICES:
400 North Lexington Ave.,
Pittsburgh 8, Pa.

Atlanta, Boston, Chicago, Houston, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco, Seattle, Tulsa.